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Looking Out to 2020: Trends Relevant to the Coast Guard

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In December 1995, the Vice Commandant of the Coast Guard asked CNA to help support the development of a capstone document that describes today's Coast Guard and includes a framework within which to portray its continued relevance to the United States. CNA responded with its Future Directions Study for the United States Coast Guard. The study focused on three issues: traditions, trends, and implications for the service as a whole. In November 1996, the Future Directions study team briefed the senior Coast Guard leadership on our initial findings. The product of the this briefing includes a discussion of Coast Guard core values and characteristics, relevant trends, and four notional end states representing the potential impact of these trends. This document supports that initial, summary presentation of trends with more detailed description of our research.

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Contents

Introduction and summary

Background

In December 1995, the Vice Commandant of the Coast Guard asked CNA to help support the development of a capstone document that describes today's Coast Guard and includes a framework within which to portray its continued relevance to the United States.[1] Because of the range of its responsibilities, the Coast Guard is connected in some way with many outside organizations also involved in the maritime environment. These are governmental (federal, state, and local) and private entities of the United States and many foreign nations. Due to this complex web of responsibilities and relationships of varying scope and significance, it is difficult to concisely explain what the Coast Guard does and what it might look like well into the next century.

CNA responded with its Future Directions Study for the United States Coast Guard. The study focused on three issues:

- The traditions, enduring qualities, and core values that define the Coast Guard and underpin its unique contributions to the Republic
- The trends (and contingencies) that will influence the nature, relative importance, and combination of future Coast Guard missions and operational relationships
- The implications for the service as a whole, given those trends and possible contingencies, and how particular future directions would translate into principles or guidelines for future operations.

In November 1996, the Future Directions study team briefed the senior Coast Guard leadership—including the Commandant, Vice Commandant, Chief of Staff, and the two Area Commanders—on our initial findings. The product of this presentation, CNA Annotated

1. Letter from the Vice Commandant, dated 20 December 1995.

Briefing (CAB) 96-96, includes a discussion of Coast Guard core values and characteristics, Coast Guard-relevant trends and contingencies, and four notional end states representing the potential impact of these trends.

Approach

This document supports our initial, summary presentation of trends in CAB 96-96 with a more detailed description of our research. We focus on trends in order to describe relevant external variables. We define trends as changes in now-identifiable phenomena, and focus our research only on those trends that are likely to affect Coast Guard missions. Countless other trends we could have examined will have no effect on the Coast Guard, cannot be tracked beyond a few years, or are not adequately supported by evidence. There are also trends that will affect the Coast Guard but are beyond the scope of this study. These are:

- Trends internal to the Coast Guard. No amount of study or exposure would confer the necessary understanding, sensitivity, and cultural awareness to justify speculation here.
- Resource availability. While it might seem logical to extrapolate today's tight fiscal environment well into the next century, we found little evidence that this will necessarily be the case.
- The shape and direction of American and foreign policies and relations. The number of possible variations one could imagine is large and diverse enough to overwhelm any analytical technique.

The first five sections of this document represent the five major trend categories that emerged during our research: societal, technological, political, economic, and environmental. We relied primarily on open-source literature and discussions with experts on various aspects of the maritime environment, in government, academia, and the private sector.

Trends are not the only external pressures affecting the Coast Guard. Contingencies also arise. They may be consistent with observable, long-term trends, but they are discrete events that take place rapidly and are likely to have an immediate impact on both the missions and the organization of the Coast Guard. Contingencies imply a greater degree of uncertainty and unpredictability than trends, so it is diffi-

cult to forecast the future of the Coast Guard based upon their occurrence. Nonetheless, they are important to consider, having profoundly affected Coast Guard organization and missions in the past.[2] CAB 96-96 describes in more detail those contingencies that would have the most dramatic effect on the Coast Guard. They include a major oil or chemical spill, an explosion in a port facility, a passenger ship disaster, repeal of the Jones Act or major maritime deregulation, war or major conflict, and a terrorist incident.

Findings

Table 1 summarizes our findings. With one exception, we found no trends that could, in themselves, fundamentally transform the Coast Guard between now and 2020. The one exception, the anticipated evolution of the Navy surface combatant force into a circa-100-ship, high-tech, deeper-draft force, could force the Coast Guard into a greater naval support role, especially in low-end conflict or OOTW scenarios. Any number of contingencies—especially those we describe—could have a dramatic impact on the Coast Guard, but their occurrence, scale, and effect are difficult to predict.

The study team had expected to find a number of trends that would bring about fundamental changes. Many of the trends we examined will, in fact, bring about significant changes in how missions are performed (especially in regard to the technologies available to the Coast Guard). However, these trends, for the most part, will not fundamentally change the type and number of missions that are performed. What this means is that the Coast Guard's future will be determined by contingencies, by congressional preferences, and by the preferences of its own leaders. With this in mind, we concluded that it would be best if Coast Guard leaders defined a course of action to achieve its desired end state.

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2. Throughout its history, the Coast Guard has undergone dramatic changes in response to contingencies: The *Titanic* sinking resulted in the establishment of the International Ice Patrol; Prohibition created additional law enforcement duties during the 1920s; the 1976 Magnuson Act banned foreign vessels from fishing in U.S. waters, sparked growth in the U.S. fishing fleet, and stressed the protection of living marine resources; and the *Exxon Valdez* oil spill resulted in the Oil Pollution Act of 1990 and more substantial environmental responsibilities.

Table 1. Coast Guard-relevant trends

Societal trends

Maritime drug interdiction is reduced.
Migrant interdiction continues as important CG mission.
Recreational boating numbers remain relatively stable.
Population growth and demographic changes pose no dramatic effects.

Technological trends

Computers continue to grow in power.
Revolutionary advances are made in materials/devices.
Explosive growth occurs in communications capabilities.
Global Positioning System (GPS) dominates navigation.
Integrated navigation systems become standard.
Sensors become ubiquitous.
Satellite surveillance is more accessible.
Remotely piloted air vehicles replace many fixed-wing aircraft.
Marine vehicles change in size and speed.
Integrated maritime information systems emerge.

Political trends

Law of the Sea (LOS) is increasingly accepted.
Piracy declines.
CG contributions to defense increase.
U.S. surface combatant force evolves.

Economic trends

Fisheries law enforcement remains important.
Off-shore resource exploitation continues.
Ocean thermal energy conversion is unlikely.
Vessels grow in numbers, size, and speed (in commerce with U.S.).
Size of U.S. flag merchant fleet declines.
Number of HAZMAT carriers (in commerce with U.S.) grows.
Number of barges and tugs grows.
Number of passenger vessels grows somewhat.
Gambling/gaming vessel numbers remain stable.
Containerized cargo is consolidated in fewer, deeper draft ports.
Traffic is congestion in certain ports.
No new deepwater ports are added; ships continue to rely on lightering.
Long-term intermodal growth occurs.
Oil traffic grows in short term, declines in long term.

Environmental trends

Arctic shipping routes could increase.
Antarctic activity changes little.
Global warming effects continue.
Concern over oil pollution increases.
Ocean dumping declines.
Concern for and protection of endangered species continues.
Emphasis on sanctuaries and "zoning" for maritime stewardship increases.

Organization of this report

In the next five sections, we focus on the trends listed in table 1. We begin section by listing the trends that are discussed in that particular section. Then we discuss our research and findings accordingly.

In several cases, research supporting one trend also supports other trends in the same or possibly different categories. For instance, technological advances discussed in one section may have a considerable effect on economic trends discussed elsewhere. Whenever possible, we will cross-reference such effects.

Societal trends

Our societal category includes the following Coast Guard-significant trends:

- Maritime drug interdiction will continue (slight reduction in levels).
- Migrant interdiction continues as important CG mission.
- Recreational boating numbers remain relatively stable.
- Population growth and demographic changes pose no dramatic effects.

Maritime drug smuggling will continue (slight reduction in levels)

Background

Narcotics industries rank among the world's most successful illegal enterprises. Narcotics operations are becoming larger, more powerful, and more enmeshed in the global economy and societies of individual states. For the United States, Colombia is of particular concern as an illicit narcotics producer. Mexico and the Caribbean region are main conduits for distribution and sale of cocaine and heroin in the United States. Other regions, such as Southeast Asia (heroin), also produce illegal drugs, but traffickers there generally do not use maritime routes to smuggle contraband into the United States.

Colombia's sophisticated, highly developed trafficking operations employ hundreds of specialized personnel, among them pilots, shippers, chemists, accountants, lawyers, business managers, and assassins. An estimated $4 billion to $7 billion is earned annually, mostly from cocaine sales in the United States and Europe. These revenues endow the narcotraffickers with resources to bribe or otherwise influence key Colombian police officials and political leaders. Corruption has reached epidemic proportions in Colombia, with thousands of drug trafficker payoffs going to national politicians, local police offi-

cials, army officers, airport police, telephone operators, prosecutors, and local government officials. U.S. estimates suggest that Colombian drug dealers "invest" some $100 million each year in bribes.

Drug money pervades the Colombian economy: it accounts for ownership of more than 10 percent of Colombia's agriculturally usable land and considerable investments in other sectors of agribusiness. In addition to serious narcoterrorist violence, the Colombian drug cartel has achieved such political power that it can destabilize the national government and affect regional and global events. As part of the national effort to curtail the cocaine trade to the United States, the Coast Guard in cooperation with other agencies and foreign governments operates a drug interdiction program throughout the Caribbean.

The Coast Guard supports international counterdrug activities and provides relevant information to the intelligence community on maritime drug smuggling activities. The Coast Guard coordinates its efforts with other federal agencies. These include the Department of Defense, for detecting and monitoring vessels and aircraft transiting U.S. waters; the Department of Justice, for criminal prosecution; the Department of State, for flag state permission to exercise law enforcement actions; and the Drug Enforcement Administration and the Office of National Drug Control Policy, to carry out counterdrug policies.

The U.S. Government drug control strategy has three separate approaches: reducing the domestic demand, reducing the supply in source countries, and reducing the supply through interdiction. The Coast Guard is primarily involved in supply reduction, through interdiction in maritime regions.

Coast Guard roles in drug interdiction

The Coast Guard is authorized to enforce or help enforce of all Federal laws applicable on, over, and under the high seas, and to waters subject to the jurisdiction of the United States. The Coast Guard also is authorized to enforce laws in support of other Federal agencies. One law enforcement activity of the Coast Guard is drug interdiction. The Coast Guard is the lead agency for maritime drug interdiction,

and shares leadership with the U.S. Customs Service for air interdiction.

The goal of this Coast Guard drug interdiction program is to eliminate maritime routes as a significant trafficking channel for the supply of drugs to the United States, through deterrence, seizures, arrests, and prosecution of persons engaged in that trade. Coast Guard cutters, ships, and aircraft conduct routine law enforcement patrols and special operations throughout the maritime area under U.S. jurisdiction, and in waters near principal source countries and transit states.

The Coast Guard's drug program stresses the interdiction of vessels smuggling cocaine, heroin, and marijuana into the United States, as well as the apprehension of aircraft suspected of carrying drugs from source and transit countries over the high seas.

For FY 1996, the Coast Guard's budget for these programs was $329.7 million, of which $315.7 million went for operating expenses to operate and maintain equipment and train and sustain personnel. Most of the remaining funds were allocated for acquisition, construction, and replacement of vessels, aircraft, and monitoring technology supporting the interdiction program. Efficient execution of this law enforcement mission requires the Coast Guard to operate an intelligence organization in support.

As shown in the table 2, annual drug seizures vary greatly. This could be explained by a number of factors: the statistics are distorted by some very large seizures (the *Nataly I* seizure in 1995 accounted for 24,325 pounds, almost half of the annual total); Coast Guard assets were diverted to other national priorities such as the mass migration emergency in 1994; and, as shown in table 3, funding levels have declined since 1991. Informal estimates suggest that on the average, perhaps only 10 percent of the traffic is apprehended.

Table 2. Drug seizures by calendar year[a]

	1990	1991	1992	1993	1994	1995	1996
Cocaine (pounds)	15,153	29,370	17,871	31,321	9,765	47,450	24,453
Marijuana (pounds)	62,279	22,145	58,525	48,441	27,050	40,964	21,850
Est. street value ($B)	3.53	4.69	3.04	4.21	1.04	2.68	1.87
Seizures	99	59	60	51	16	23	34

a. Sources, U.S. Coast Guard Office of Law Enforcement, January 1997.

Table 3. National Drug Control Budget—Interdiction, FY 1990–96 (in $M)[a]

	1990	1991	1992	1993	1994	1995	1996
Coast Guard	661.2	714.6	431.2	308.1	313.6	300.3	329.0
All Federal agencies	1,751.9	2,027.9	1,960.2	1,511.1	1,311.6	1,280.1	1,339.4

a. Source: White House, National Drug Control Strategy 1996.

The Coast Guard Intelligence Coordination Center has assumed the lead in evaluating maritime activities for the Interagency Assessment of Cocaine Movement, which aims to target drug trafficker assets and personnel. The Coast Guard also deployed mobile training teams to source and transit countries to improve the law enforcement capabilities of those governments. During 1995, these teams trained some 700 foreign nationals in 15 countries.

New technologies for nonintrusive detection were also deployed, tested, and perfected in the field as part of the interdiction program. Currently, 15 IONSCAN instruments are being used by Coast Guard boarding teams to detect hidden cocaine shipments. In addition, over 20 units of the Compact Integrated Narcotics Detection Instrument (CINDI) are being deployed to help detect drugs being shipped at sea.[3]

International operations and agreements

In 1995 the Coast Guard participated in multinational task force operations within the Caribbean and in Central and South America. U.S. Coast Guard Law Enforcement Detachment members regularly embarked on patrolling vessels belonging to the U.S. Navy, the United Kingdom, and the Netherlands in the Caribbean.

With respect to international law, counterdrug agreements have been signed and implemented with the following governments: Antigua/Barbuda, Bahamas, Belize, British Virgin Islands, Dominica, Dominican Republic, Granada, Netherlands Antilles, Panama, St. Kitts/Nevis, St. Lucia, St. Vincent and the Grenadines, Turks and Caicos islands, United Kingdom, and Venezuela. Conspicuously, the governments of Colombia, Peru, Ecuador, and Bolivia—principal narcotics source countries—have been presented with, but have so far refrained from concluding, such agreements with the United States. The agreement with Mexico does not contain a maritime component.

These agreements give the U.S. Coast Guard significant lawful rights. Besides mutual pledges to cooperated in combatting maritime drug traffic "to the fullest extent possible," the agreement permits U.S. law enforcement personnel, including Coast Guard representatives, to participate in a combined law enforcement shiprider program. In this program, qualified law enforcement personnel of the foreign government may embark on U.S. Coast Guard and Navy vessels as they patrol the region. Likewise, U.S. law enforcement personnel, including Coast Guard representatives, may sail on vessels of the other state conducting counter-drug patrols. Important also, U.S. vessels are authorized to conduct counter-drug patrols in the territorial waters of the foreign state and to assist foreign law enforcement officials in boarding of suspect vessels. They may also enforce the laws of the United States seaward of the territorial sea (i.e., in the exclusive economic zone) of the foreign state. The doctrine of hot pursuit is also reaffirmed in these agreements. Thus U.S. law enforcement vessels are

3. IONSCAN and CINDI are electronic devices that enable boarding teams to detect hidden compartments and to detect very low levels of narcotics residue, respectively.

authorized to pursue suspect vessels or aircraft into the territorial waters of the foreign state.

These agreements represent an important legal step for regional cooperation toward apprehending drug smugglers in the Caribbean. The most notorious source countries do not participate, however, thereby undercutting prospects for significant success.

Future trends

Maritime drug smuggling will continue

Most of the cocaine that reaches the United States has traditionally arrived from Colombia via Mexico. In recent years, the U.S. Government has shifted its law enforcement efforts to suppress that route. In reaction, the drug cartels have similarly shifted to the eastern Caribbean for new shipment routes. Since 1990, cocaine seizures in the Caribbean have quadrupled to 18 tons annually. Today, the U.S. Drug Enforcement Administration estimates that more than 100 major traffickers are using Caribbean islands as storage and distribution points for U.S. and European markets.

The new center of the Caribbean drug trade is Puerto Rico. As a U.S. commonwealth, Puerto Rico has an advantage in that its cargo is only superficially checked by customs officials before it enters the U.S. mainland. Over the next decade, Puerto Rico may become the major entry port for illegal narcotics, principally Colombian cocaine, entering the United States.

By 2020, the Caribbean route could be the principal channel for illegal narcotics being smuggled into the United States, by air and sea. It is even conceivable that by 2020, some Caribbean island states could be taken over by some international drug groups. In any case, the role of drug money will grow and influence the economies and politics of these micro-states and the rest of Latin America. Cocaine, heroin, and marijuana will continue to be major cash crops and industries in Colombia, Bolivia, Peru, and Mexico. By 2020, Jamaica, Panama, and the Bahamas may also emerge as significant drug producers in the region. Narcotics trafficking will continue as the drug trade prolifer-

ates and affects more people in more countries throughout Latin America and the Caribbean.

Although the Caribbean still appears to be the most likely future route for maritime drug smuggling, law enforcement agencies are currently witnessing an increase in the volume of smuggling in the Eastern Pacific and into Mexico for further shipment into the United States. Because of the vast area involved and the fact that the heaviest interdiction efforts are in the Caribbean, traffickers have begun to smuggle very large loads of cocaine through the Eastern Pacific, hidden aboard both commercial and non-commercial vessels.

Levels of maritime drug smuggling are slightly lower

The level of maritime drug smuggling will decrease slightly due to several reasons. First, the focus of the U.S. drug market appears to be shifting from cocaine to heroin. Latin American drug trafficking organizations that previously dealt in cocaine are entering the heroin market. Heroin is more concentrated than cocaine and requires smaller shipments for equivalent doses, reducing the need for large-volume transportation, including ships and boats. If heroin use increases at the expense of cocaine, maritime drug smuggling will likely decline in favor of air and courier shipments.

Second, synthetically manufactured drugs, such as methamphetamines, are being manufactured in clandestine laboratories in the United States and Mexico. In certain regions of the United States, methamphetamine has replaced cocaine as the drug of choice. If this proportional rise in domestically produced drugs persists, maritime smuggling will be reduced.

Third, to the extent that drug control remains a national priority and funding remains adequate, education and rehabilitation efforts may, in time, reduce the demand for illegal drugs.

Implications for the Coast Guard

It is clear that drug traffickers will continue to adapt to new interdiction strategies and new technologies, so the Coast Guard's drug interdiction efforts must remain flexible and nimble.We believe that international agreements and combined and interagency operations

will continue to help combat illegal drug smuggling. The traffic is likely to persist, but the Coast Guard can play an important role in reducing the extent to which traffickers choose maritime routes.

Migrant interdiction remains a Coast Guard mission

Introduction

Why is illegal immigration a problem?

One source described the problem of illegal immigration in the following terms:

> ...new walls are being erected, not between geopolitical blocks, but between lands of affluence and lands of poverty....(Former) Senator Alan Simpson (R-WY) has put it rather starkly: "The first duty of a sovereign nation is to control its borders. We do not....Uncontrolled immigration is one of the greatest threats to the future of this country."[4]

The magnitude of immigration to the United States has significantly increased in the past four decades. Since 1950, the number of *legal* immigrants admitted annually to the United States grew from 250,000 to over 800,000; *illegal* immigration adds at least another 200,000. As a result, immigration now accounts for at least 40 percent of U.S. population growth, vice 9 percent in 1950.[5, 6] Clearly, if the

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4. Peter Andreas, "The Making of Amerexico: (Mis) Handling Illegal Immigration." *World Policy Journal,* Vol. 11, No. 2, Summer 1994, pp. 45–56. Simpson quote from: Carlos Rico, "Migration and U.S.-Mexican Relations," in *Western Hemisphere Immigration and United States Foreign Policy,* ed. Christopher Mitchell (University Park, PA: Pennsylvania State University Press, 1992), p. 256.

5. The number of illegal immigrants entering and remaining in the U.S. is difficult to measure. The Census Bureau estimates 225,000 annually and other estimates range from 100,000 to 350,000. Jennifer Cheeseman Day. *Population Projections of the United States by Age, Sex, Race, and Hispanic Origin: 1995 to 2050,* U.S. Bureau of the Census, Current Population Reports, P25-1130 (Washington, DC: U.S. Government Printing Office, 1996), p. 28.

United States wants to manage its population growth, it must obtain better control of immigration. According to one recent study,

> Today, virtually every nation that traditionally accepted immigrants is changing its laws. Political opposition to immigration is increasing. Events such as China's failed democracy movement, Haiti's military overthrow of the Aristede government, and the breakup of the Soviet Union and Yugoslavia have all produced vast numbers of emigrants seeking new homes.[7]

Although most media coverage and expressions of public concern focus on movement across the U.S.- Mexico border, immigrants and smuggling organizations also use maritime routes to enter the United States, or intermediate points in the Caribbean and Central America. Daily, immigrants leave Haiti, Cuba, and the Dominican Republic by boat, bound for the United States. Organized crime groups smuggle migrants by ship from the Peoples' Republic of China (PRC) to the United States or to our neighbors for transshipment via other transportation modes into the United States. "Hundreds of thousands of illegal migrants are currently being moved by international criminal smuggling syndicates from their countries of origin to Western Europe and the United States."[8]

Factors that can drive illegal immigration

A number of factors can "push" people out of their home countries: war, political instability, natural disasters, and incentives such as educational opportunities and reunification with family. Weak economic opportunities in source countries and perceived greater opportunities in the United States may be the strongest motivation. One study of factors affecting immigration found the relationship between a

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6. George J. Borjas, "The Immigration Problem," *Jobs and Capital*, Summer 1994, Vol. 3, feature article 7 (Santa Monica, CA: Milken Institute for Job and Capital Formulation).

7. Suzanne M. Dale, Michael C. LeMay, Al G. Mariam. "Breaching the barriers: migrating ethnic groups and immigration policy," *Southeastern Political Review*, Vol. 22, No. 4, Dec 1994, pp. 729–52.

8. Presidential Initiative to Deter Alien Smuggling: Report of the Interagency Working Group.

decrease in source country earnings and an increase in illegal immigration as close to unit elasticity.[9]

Even China—where the economy is growing rapidly, but only in some regions—has become an important source of illegal immigration. In 1996, Chinese were paying smugglers up to $35,000 for transportation to the United States.

A mass migration to the United States from PRC or another nation outside of the Western Hemisphere is unlikely given the long distances to the United States or other suitable receiving countries. Nonetheless, mass migrations from Western Hemisphere countries have occurred and can occur again. A mass migration can be inspired by political instability (e.g., overthrow of President Aristede in Haiti), natural disaster, war (Guatemala), or government policy (Cuba and Haiti).

In the early 1980s, the governments of Haiti and Cuba deliberately inspired mass migrations. Castro encouraged a mass migration by concurrently dropping the barriers to emigration and encouraging prisoners and other undesirables to leave Cuba. Of the 125,000 immigrants who subsequently entered the U.S., almost a fifth were or had been prisoners in Cuba.[10] In Haiti, the Duvalier regime made no attempt to inhibit the migrant flow from Haiti until the U.S. agreed to augment its foreign aid. One author states:

> In the Cuban cases [1980 and 1994] it was clear that the Castro government had engineered a flow to suit its own domestic or foreign policy needs, while the Haitian case [early 1980s] demonstrated how a government could use the flow to influence U.S. foreign aid policy.[11]

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9. Bernt Bratsberg, "Legal versus Illegal U.S. Immigration and Source Country Characteristics," *Southern Economic Journal,* Vol. 61, No. 3, Jan 1995, pp. 715–27.

10. Alex Larzelere. *The 1980 Cuban Boatlift* (Washington, DC: National Defense University Press, 1988) p. 221–226.

11. Michael S. Teitelbaum and Myron Weiner, editors. *Threatened People, Threatened Borders: World Migrations and U.S. Policy* (New York: W.W. Norton & Company, 1995), p. 18.

Political/legal efforts to stop illegal immigration

Current U.S. immigration laws attempt to balance protection of human rights with orderly legal immigration. However, they have not been particularly effective in preventing or stopping illegal immigration. For migrants, there are few disincentives for entering the United States illegally. If caught and returned to their homeland, illegal migrants often repeat efforts to cross the border. Illegal immigrants arrested in the U.S. become eligible for immigration hearings. They are normally released on parole, but often fail to return for their scheduled hearings. Instead, they disappear into the general population. The Immigration Control and Reform Act of 1986 attempts to solve this problem by establishing sanctions against businesses that employ illegal aliens, but these sanctions have not been vigorously enforced.

In the 1980s, the U.S. Government increased Coast Guard interdiction and deterrence efforts in response to illegal immigration from Haiti. One study found that "The deterrent effect was considerable. In 1980 alone, 24,530 undocumented Haitian migrants—mainly boat people—were arrested in south Florida; over the succeeding eight years, a total of only 21,906 were apprehended there."[12]

Diplomacy can also affect migration rates. One study states, "Unilateral, bilateral, and multilateral policies may stimulate or reduce movements of people from one country to another. In recent examples, diplomacy and military intervention reduced migration from Cuba and Haiti."[13]

Migrant smuggling by organized crime

Criminal organizations are entering the migrant smuggling business, apparently motivated by opportunities for great profits with low risks.

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12. Christopher Mitchell, "U.S. Policy toward Haitian Boat People, 1972-93," *Annals of the American Academy of Political and Social Science*, Vol. 534 (Thousand Oaks, California: Sage Publications, July 1994), pp. 69–80.

13. Teitelbaum and Weiner, p. 302.

Illegal immigrant smuggling from the PRC by organized crime organizations is growing, as noted below:

> China is also a major source of organized illegal migration, and human smuggling, facilitated by criminal syndicates, has become big business—on a global basis rivaling if not overtaking illegal drug trafficking in dollar volume—and a major international security concern.[14]

During 1981–90, only 28 Chinese were interdicted; in 1991–96, 4,270 were interdicted. Individually, these smuggling events usually involve more migrants than those typical of the Caribbean. In contrast to small boats and rafts frequently used in the Caribbean, these Chinese often use converted longline fishing vessels or small freighters. In 1993, *M/V Eastwood* was interdicted 1,600 miles southwest of Hawaii as it was attempting to smuggle over 500 PRC immigrants to the United States.

Alien smuggling is a growing trade, with billions of dollars in annual profits. Trafficking organizations operate with near impunity, as alien smuggling is a crime in only a few recipient and transit countries and the penalties are relatively low. Corrupt officials abroad are another factor. Immigration directors in Belize, Panama, Guatemala, and the Dominican Republic have been removed from their positions for corruption.

Current CG role in preventing illegal immigration

The Coast Guard has interdicted over 148,000 undocumented immigrants from 33 countries since the migrant interdiction program began in 1981. This effort has reduced the estimated overall number of illegal immigrants by about 5 percent. The Coast Guard prevents illegal immigration by maintaining cutters and aircraft on patrol in forward regions and by responding to cued intelligence on potential migrant and smuggling events. In the Caribbean, forward presence patrols and surveillance are particularly effective due to the frequency of smuggling events and because geographic choke-points cause transit routes to focus on a few key areas. Outside of the Caribbean region most interdiction operations rely upon cued intelligence instead of barrier-type patrols.

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14. Teitelbaum and Weiner, p. 83.

The three primary immigrant source countries in the Caribbean currently are Cuba, Haiti, and the Dominican Republic. As discussed below, recent mass migrations from Haiti and Cuba have resulted in the Coast Guard interdicting over 60,000 illegal immigrants. Although mass migration events are episodic, small groups of illegal migrants, operating independently or aided by smugglers, routinely attempt to reach the United States by maritime routes. Haitians and Dominicans often attempt the 60-mile transit across the Mona Passage between the Dominican Republic and Puerto Rico in small craft called yolas. Cubans seek to sail across the 60 to 90 miles between Cuba and the Florida Keys in all types of boats, from homemade rafts and jury-rigged sailing craft to hijacked public vessels. Table 4 shows the number of illegal immigrants interdicted by the Coast Guard since 1990.

Table 4. Illegal immigrants interdicted by the Coast Guard, 1990–96

	Haiti	Cuba	DomRep	PRC	Other
1990	1,124	430	1,247	0	25
1991	10,087	1,936	1,455	138	36
1992	31,434	2,336	436	793	44
1993	2,404	3,653	585	2,511	38
1994	25,059	37,188	812	348	5
1995	2,336	611	3,847	442	36
1996 (to Sep)	706	281	4,731	38	25
Total	73,150	46,435	13,113	4,270	209

The "Other" column in table 4 includes migrants from Colombia, India, Pakistan, Peru, Ukraine, Jamaica, Poland, Brazil, Ecuador, and Yugoslavia.

Central America is a major conduit and source of illegal migrants entering the United States. In additional to being the source of illegal aliens, it has emerged as a transit route for some 100,000 aliens from outside the region (primarily Chinese and South Asians). These migrants are normally brought to Central America by ships that offload at isolated points along the coasts, for subsequent transport into the United States via air or land. Smugglers and migrants look for the weakest links in the U.S. border for entry; recently they have entered

across the U.S.-Mexico border, or through Puerto Rico via the Dominican Republic. To minimize their risk they choose transshipment nations with weak or no prohibitions against migrant smuggling. For example:

> Also arriving in recent months [in Dominican Republic] has been a trickle of Cuban boat people who first landed in Jamaica and Bahamas but moved on when those governments began deporting people to Cuba earlier this year....what most of them want is a ticket to Miami and a U.S. visa.[15]

Recent mass migrations: Cuba and Haiti

In the 1980s and 1990s, the Coast Guard responded to mass migration emergencies from Haiti and Cuba. Over 32,000 undocumented Cuban immigrants were interdicted as they attempted to flee the deteriorating conditions in Cuba in August and September 1994. This was the most significant migration from Cuba since the 1980 Mariel Boatlift, during which about 125,000 Cubans landed in south Florida.

Since 1980, over 94,000 people have fled Haiti. In the two most recent Haitian mass migrations in 1992 and 1994, 37,618 and 25,302 migrants were interdicted, respectively. It appears that Haitian migrant interdictions peaked after U.S. court actions suspending repatriations and other changes to immigration policy were announced or perceived.

Future trends

Demographic

Over the next 25 years, the world's population may grow by as much as one billion people per decade; most of this increase will occur in the underdeveloped world. As people are crowded into areas with limited ability to support them, many will be inspired to move to more prosperous regions within their own country or abroad.

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15. Juan O. Tamayo, "Nation is 'Perfect Waiting Room' for Passage to Miami," *Miami Herald,* July 15, 1996.

A recent UN survey found that the gap between rich and poor nations is widening.[16] This gap is likely to continue to grow, providing stimulus for continued illegal immigration as a result of the "economic pull" of the United States.

Additionally, to the extent that enforcement efforts are increased to prevent illegal immigration via land and air routes, migrants and smuggling organizations will increasingly use maritime routes. As one study said, "Enforcement improvements in one area merely shift points of entry to the path of least resistance."[17] An Associated Press report concurs:

> ...the Border Patrol's strategy of saturating populated ports of entry is driving illegal immigrants to more remote and dangerous desert areas.[18]

Political/legal/social

Society's growing concern with the perceived problems of immigration could cause U.S. immigration laws to tighten. Some changes could aid the Coast Guard's interdiction effort by improving interdiction authority (special exclusion) or increasing the sanctions against smuggling. Other changes may reduce the number of legal migrants, potentially increasing the number of illegal migrants and providing additional stimulus to migrant-smuggling organizations.

Illegal-alien smuggling is an international problem. Migrant smuggling could be reduced if countries adopted laws making alien smuggling a crime. Bilateral agreements with source and transshipment countries providing for cooperative interdiction and acceptance of repatriation could make interdiction operations easier and could deter illegal immigration.

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16. Barbara Crossette, "U.N. Survey Finds World Rich–Poor Gap Widening," *New York Times,* July 15, 1996.

17. Michael D. Emerson. *Raising the Guard Against Illegal Migrants Along the Coast,* Thesis (Quantico, VA: Marine Corps University, 1996).

18. Associated Press, *Deaths of Illegals in Arizona,* July 15, 1996.

It appears that illegal immigration, aided by smuggling organizations will continue into the foreseeable future. However, one can easily imagine two scenarios that would affect the Coast Guard's migrant interdiction mission.

If domestic opposition to illegal immigration grows sharply, and tolerance for illegals correspondingly declines, the Coast Guard will need more resources, to enforce a more robust anti-immigration plan. It seems highly unlikely that such a policy could be sustained for more than a short period of time (perhaps in response to a major, visible immigration incident that impelled the government to act). One source states:

> In terms of threat perception, the most problematic migrations seem to be those taking place in boats—not because the numbers involved are higher than those crossing land borders (the reverse is true), but because of the greater concentration, vulnerability, and "tele-visibility" embodied in mass movements undertaken in small boats and homemade rafts.[19]

A change in U.S. law to combat illegal immigration domestically through a combination of effective punishment for violating immigration laws and an equally effective repatriation/deportation program might help reduce the flow of illegals, including those coming by sea.

Coast Guard ICC assessment

The Coast Guard Intelligence Coordination Center publishes an annual threat assessment for Coast Guard operational law enforcement missions, including illegal maritime immigration. The paragraphs below summarize their projections:

> China (PRC), Cuba, the Dominican Republic, and Haiti will be the main source countries for illegal maritime migration to the United States. Cuba and Haiti will also be used as transit points for illegal aliens seeking to enter the U.S. by sea. The Bahamas, Central America, Dominican Republic

19. Teitelbaum and Weiner, p. 22.

and Puerto Rico will remain major transit points for illegal maritime migration to the United States.

It is likely that Haiti's crushing poverty will continue no matter what political system controls the country. Haiti is the poorest country in the Western Hemisphere, and will remain so for the foreseeable future. Even if democracy takes hold in Haiti, and future elections are legitimate, we assume that future migration rates will mirror the historical rates of 100–200 per month seen in the 1980's. We assume that countering the threat of a mass migration from Haiti will remain a high priority to the present and future U.S. administrations."

While we believe that global migration will expand worldwide, we judge that other than from the source countries noted [Cuba, Haiti, Dominican Republic, PRC], there will be no *large scale* maritime illegal migration to the United States. However, undocumented aliens worldwide will continue to attempt to reach the U.S. by air and land. [20]

Implications for the Coast Guard

The Coast Guard can continue to be the primary and most effective instrument in managing mass migration problems. However, unless illegal migration becomes a matter of national priority, the Coast Guard can do little more to stem maritime immigration than it is currently doing now.

Migrant interdiction remains a Coast Guard mission

If the now-escalating differences between first- and third-world countries continue, illegal immigrants will continue to attempt to reach the United States. Their transportation modes will be determined by cost and effectiveness; maritime routes will increasingly become the routes of choice as smuggling becomes more profitable and if other transportation routes become more difficult through increased enforcement efforts. Because the priority to protect our borders from illegal immigrants will likely grow, the Coast Guard will continue to be

20. *A Look Ahead to the Future Environments for Coast Guard Operational Law Enforcement Missions, 1996 Update* (Washington, DC: U.S. Coast Guard Intelligence Coordination Center, April 1996), pp. 5, 15.

called upon to interdict illegal migrants at sea and to deter them through forward presence.

We will retain our national capability to respond to mass migration events

The United States will continue to need resources and capabilities to respond to future mass migrations. Although events are difficult to predict, it is likely that some nation close to the U.S. could experience a political coup, natural disaster, failed economy, or other crisis that could prompt a sudden mass migration to the United States. Like previous mass migrations, interdiction at sea will be our first line of defense and will be led by the Coast Guard.

Organized smuggling increases in quantity and sophistication

As the demand for migration into the United States increases while traditional methods and routes for illegal migration are curbed, more smuggling organizations will enter this highly profitable enterprise and existing ones will expand their current operations. Additionally, with increased enforcement efforts against current immigration modes and routes, the smugglers will adopt more sophisticated routes and methods, thereby increasing the difficulty of interdicting migrants. In the same way that narcotraffickers became more sophisticated in the 1980s, migrant smugglers are finding ways to evade our efforts to interdict and disrupt smuggling.

Recreational boating numbers remain relatively stable

The 1996 Annual Sailing Business Report states that the recreational boat market is slowly recovering from the down-trends experienced during the early 1990s. Recreational boats are big-ticket discretionary items. Factors that could influence the boating industry include repeal of luxury taxes, a rise in consumer confidence, declining living standards, increases in personal income, or a change in interest rates and inflation—i.e., real economic growth. Demographic factors and the long-term decline in productivity growth suggest that the rate of economic growth will continue to decline as will real wage and income growth.[21]

The next decade is forecasted to be an era of slow and small economic growth.[22] Real gross domestic product is expected to increase by only about 2.3 percent per year from 1990 to 1998.[23] Another forecast suggests that economic grow will remain at 2.6 (still low). The slow economic growth and weak consumer confidence discussed above suggest that any growth in recreational boating will be slow and small—marginal at best, and flat the most likely case.

The most likely forecasts predict a long-term "retrenchment" (probably small) in recreational boat demand based on changes in demographics.[24] The U.S. Labor Department notes that young adults (25 to 34 years old) now account for 56 percent of the total spending on recreational boating products. Statistics also indicate that married couples without children account for 58 percent of the total spending on boating products. Together, these two factors suggest that as the Baby Boom Generation matures, those demographic groups that account for most boat sales will shrink. Further, households in the Northeast and Midwest account for 75 percent of spending on recreational boating. However, these same areas are losing population to the South, the Southwest, and the West Coast.

Recent surveys indicate that consumers value vacations, personal computers, and televisions more than boats. Most categories of recreational boat sales have been down—except for canoes, personal watercraft, small outboards, and used boats. Beyond the resale and retail markets for recreational boats there are growing opportunities for time-shares and boat rentals. Thus, although the number of recreational boats won't change, the frequency of their use could.

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21. The rate of real economic growth is slowing. From 1960 to 1981 the average annual rate of real economic growth was 3.2 percent. Between 1981 to 1990 the average rate was 2.6 percent.

22. Liz Defranco, "Sailboat Production Rose Moderately in 1995," *Boating Industry*, April 1996: p. 10.

23. Rolf Anderson. *Atlas of the American Economy.* Washington, DC: Congressional Quarterly, 1994.

24. Doug Henschen, "Boating's Future? There's Good News and Bad News," *Boating Industry*, February 1994, p. 6.

Whatever happens to the number of recreational boats, it should pose no change to Coast Guard's search-and-rescue (SAR) mission. However, the Coast Guard may get more involved in regulating personal water craft (e.g., jet skis). These craft are for thrill sports and are dangerous (to the user and others in the water) because they are very fast, unregulated (e.g., no helmets), and appeal to young, uneducated boaters.

Population growth and demographic changes pose no dramatic effects

Extrapolating from presently observable sociological factors, futurologists speculate about a more ethnically diverse America; a higher proportion of undisciplined individuals in the younger, less educated population; more people living longer; and gradual differentiations between the literate and technically capable and others. If, for the sake of analysis, however, one assumes a continuing need for some 40,000 active Coast Guard personnel, then many of these trends have little direct importance. There will be five million more men and women in the 20-to-24-year-old age group, more than a third more than at present. Thus, even if a smaller proportion of the total pool is available or suitable for the Coast Guard, the larger size of the pool should assure that adequate numbers are available. Stated otherwise, it should be possible to recruit a professional Coast Guard from a population of between 288 and 357 million Americans.

The larger and healthier older population, however, portends higher retirement costs. It could also result in longer retention of Auxiliary personnel.

Technological trends

We began this area of research by examining recent surveys of technology trends. In particular, we examined several surveys produced for the Department of Defense and reviewed a considerable amount of science journalism, including articles in publications such as *Scientific American* and *New Scientist.* It was necessary to scan additional literature that focuses on forthcoming technological developments. Among the key studies examined were those prepared for agencies of the Department of Defense. Among the studies examined were a recent study of technology trends by the U.S. Air Force Scientific Advisory Board, *New World Vistas,* and studies of Army technology, including a report prepared by the Deputy Assistant Secretary for Research and Technology (SARD–ZT), *Army Science and Technology Master Plan,* December 1994.

We were especially interested in identifying changes in key technology likely to have an impact on the Coast Guard. In this respect, we concentrated on activities that would change the way the Coast Guard undertakes traditional missions, as well as on technologies that would affect the importance of particular missions.

Coast Guard-relevant technological trends include the following:

- Computers continue to grow in power.
- Revolutionary advances are made in materials/devices.
- Explosive growth occurs in communications capabilities.
- GPS dominates navigation.
- Integrated navigation systems become standard.
- Sensors become ubiquitous.
- Satellite surveillance is more accessible.
- Remotely piloted air vehicles replace many fixed-wing aircraft.
- Marine vehicles change in size and speed.
- Integrated maritime information systems emerge.

Computers continue to grow in power

Computers are an enabling technology for a host of applications. They make possible more capable and versatile sensors and are responsible for many improvements in communications. The design of new materials and more advanced aircraft and ship designs will depend both on the modeling and simulations possible with more powerful computers and on the possibilities offered by embedded computers to make materials and platforms smarter.

The power of computers is expected to continue to increase at a rapid pace. Those who follow the computer field rely on a rule of thumb known as Moore's Law, which states that the power of new microprocessors doubles every 18 months. According to one estimate, since the late 1950s, the power of computers has grown 100,000 times and the cost has dropped 1,000 times in real terms. This trend is expected to continue indefinitely into the future, although in the early 1990s the pace accelerated from an improvement rate of 35 percent per year to one of 55 percent. As a result, by 1995 it was possible to acquire computers with the capabilities predicted (in 1990) for 2000.[25]

As capabilities continue to grow and prices continue to drop, increasingly powerful systems become available for a wide array of uses. By 2020, one estimate is that a desktop computer will be 100,000 times as powerful as those available in 1995. The technologies that will enable faster and more powerful computers will change over time.

Even as computers become more powerful, they are expected to become more ubiquitous. They also are expected to change in character. The utility of computers will grow as they are networked together. Increasingly, computers built into other machines are expected to become common. Thus, many materials will be manufactured with embedded computers that will give some limited intelligence to the material and allow it to react to changes in the

25. David A. Patterson, "Microprocessors in 2020," pp. 1–7, in *Scientific American; Key Technologies for the 21st Century* (New York: W.H. Freeman and Company, 1996).

environment. One key example of the expanding role of computers is micromachines (discussed in more detail in the next section).

Equipment intended to replace existing technologies will appear. For example, reductions in memory, display, and computation costs should make it possible to produce low-cost navigation systems, suitable for use by recreational boaters, that integrate GPS with comprehensive libraries of charts.

Similarly, the traditional roles of computers are expected to grow. More powerful computation capabilities will enable increasingly sophisticated design of specialized materials and of systems that use those materials.

Implications for the Coast Guard

Computers are an enabling technology. Improved computational capabilities will affect virtually every aspect of Coast Guard activity. As computers get smaller and more powerful, a greater range of tasks can be affordably assigned to them. The growing capabilities of computers will cause changes in the ways that we use computers. The now familiar graphical interface is likely to change dramatically during the next few decades, as new interface paradigms are developed and adopted.

As important as the computers we will address directly are those that will be embedded into many of the tools we use. Computers will be built into the materials we use to build machines and structures, enabling those objects to become smarter.

Explosive growth occurs in communications capabilities

Discussion

Communications is another critical enabling technology. Communications technology is undergoing significant transformation at an extremely rapid pace. The emergence of new systems for communications, together with the rapid expansion of the size of communications pipelines (bandwidth), appears likely to have a revolutionary impact on economic activity. As a result, the communications systems

available to the Coast Guard and to commercial and recreational maritime operators will change dramatically in the coming years.

From the perspective of the Coast Guard there are two aspects of this transformation. First, there are innovations in maritime communications systems that are affecting both the maritime industry and the Coast Guard. Second, there are commercial developments that will affect the domestic telecommunications market and that are likely to have an impact on the Coast Guard.

The initial stages of the new developments in the maritime arena are already clear, as are many of the implications. International Maritime Organization (IMO) regulations require that by 1999 commercial ships operate a satellite communications link. New INMARSAT communications satellites using digital technologies provide computer networking and text communications capabilities.[26]

Similarly, improvements in emergency position indicating radiobeacons (EPIRBs) are providing an automated communications system to assist in search and rescue. The latest EPIRBs, which operate in the 406-megahertz radio band, are designed to operate with satellites, including polar orbiting satellites that are part of the COSPAS-SARSAT network operated by the United States, Russia, Canada, and France. COSPAS–SARSAT satellites can determine the location of an EPIRB signal to within two to five kilometers. In addition, NOAA's geostationary GOES weather satellites also are capable of detecting 406-MHz EPRIRB broadcasts, but cannot determine location.

Developments in the domestic and international telecommunications industry, however, suggest even more dramatic implications. Telecommunications technology is providing significantly new capabilities. First, new types of telecommunications systems are entering service. Wireless systems are taking increasing market share, buoyed in part by new, more capable cellular systems. It is estimated that at least 30 percent of the telecommunications market will be wireless in 2000.

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26. "Taking a new look at ship/shore communications links," *Marine Log*, March 1996, pp. 58–66.

According to some estimates, wireless communications systems eventually could account for 80 percent of all telecommunications. According to the USAF Scientific Advisory Board, "Wireless LANS will provide instant infrastructure for quick provisioning of networks. Such capabilities will be obviously important to military operations."[27]

New commercial satellite communications systems also will have a significant impact on telecommunications in the early years of the next century. Several satellite communication systems have been proposed. These systems will consist of constellations of small satellites operating in low earth orbit capable of providing cellular communications service to hand-held portable telephones. These systems, if they enter service, will provide global voice and data service. Some of the systems currently in development are described in table 5. At least some of these systems are certain to enter service.

Second, communications bandwidth is growing at exponential rates, and costs are dropping as well. As a result, one source estimated that "without spending any more money, capacity can be doubled every three years."[28] Another estimate is that bandwidth will increase between five and 100 times faster than the increases in computer speeds.[29] This is clearly true for fiber optic cable, where the intrinsic bandwidth is estimated to be 1,000 times greater than the currently used bandwidth. Current fiber optic cables carry about 2.5 gigabits per second, with 10-gigabit-per-second systems about to enter commercial service. Yet, one source estimates that, during the next decade, it will be possible to send 1,700 gigabits per second through a single cable. Technology appears available to further expand the bandwidth of fiber optic cable.[30]

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27. U.S. Air Force Scientific Advisory Board, *New World Vistas: Air And Space Power for the 21st Century—Information Technology Volume*, May 1996, p. 20.

28. Ibid., p. 18.

29. Ibid., p. 59.

30. Ibid.

Table 5. Proposed satellite communications systems[a]

	Planned year in service (IOC)	Comments
Teledisc	2001	$15 billion system consisting of 900 satellites orbiting at 700 kilometers to provide telephone and data.
Iridium	1998	$3.4 billion system consisting of 66 satellites at 780 kilometers providing global digital cellular phone service.
M–Star	2000	$6.4 billion data system with 72 satellites at 1350 km.
Global Star	1997	$1.88 billion system with 48 satellites at 1390 kilometers providing global cellular voice and data.
Ellipso	1998 (?)	Voice and RDSS for U.S.
Odyssey	1999	$1.3 billion system with 12–15 satellites at 10,354 kilometers providing voice, paging, and messaging services.
Constellation	1994	Low-cost RDSS for U.S.

a. Source: U.S. Air Force Scientific Advisory Board, *New World Vistas: Air And Space Power for the 21st Century—Space Applications Volume*, May 1996, p. 59.

Future developments are expected to significantly expand the communications capabilities of wireless systems. One technology currently available is the commercial direct broadcast system (DBS)—a satellite digital communication system capable of transmitting more than 100 video channels to an 18-inch receiver. DBS is receive-only. Future developments are expected to permit two-way communications with such systems. The U.S. military has adopted commercial-type DBS technology for applications where high-bandwidth receive-only technology is needed.

An example of the greater bandwidth that is possible through use of new satellite technologies is the M–Star global satellite system proposed by Motorola, a $6.4 billion data satellite system that would oper-

ate in the 40- and 50-GHz frequency range. The 72-satellite constellation would provide 43,000 "E–1" channels, each capable of transmitting 2 megabits per second, and 1,500 "OC–1" channels, each capable of transmitting 52 megabits per second.[31]

Further in the future, some experts believe that laser communications systems will be capable of providing bandwidth comparable to that of fiber optic cables. Hence, it might be possible for remote facilities or ships to sustain communications links requiring substantial transfer of data.[32] Laser systems, however, are limited by weather conditions, since lasers cannot travel through clouds or fog. This may preclude their use in the maritime environment.[33]

Implications for the Coast Guard

These trends are well developed, and it appears likely that by the early 21st century communications to and from ships in the most remote parts of the world will be little more difficult than communications with boats on the coastal waterways, automobiles, or even individuals.

The net result will be communications systems capable of handling much of the growth in data generation from new generation sensor networks. In addition, it will be possible for field activities to be as tightly linked to data sources as to headquarters.

When operating within the terminatory of the United States, or near its shores, the Coast Guard will benefit from the emergence of high-bandwidth commercial wireless communications systems. The Coast Guard already makes extensive use of commercial cellular telephone systems to supplement existing radio communications. This use will grow as the Coast Guard develops additional requirements for connectivity. Such systems will grow in capability.

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31. Joseph C. Anselmo, "Motorola Unveils New Satcom Plan," *Aviation Week and Space Technology*, September 16, 1996, p. 35.

32. Discussed in U.S. Air Force, *New World Vistas: Air and Space Power for the 21st Century, Summary Volume*, 15 December 1995, pp. 20–22.

33. Ben Iannotta, "Some See Optical Spectrum as Wave of the Future," *Space News*, July 8–14, 1996, p. 11.

A significant problem for the Coast Guard, however, is that the bandwidth available in the oceans is likely to be more limited than what will be available near major urban centers. Capacity will be driven by commercial considerations, and this will result in a concentration of bandwidth where the demand exists. The emergence of global satellite communications systems will provide enhanced capabilities away from the coasts, but the overall bandwidth is likely to remain more constrained than the bandwidth available in built-up areas. The Coast Guard shares this problem with the U.S. Navy, and some kind of shared solution may be necessary.[34]

In addition, the improved communications connectivity is likely to affect many routine Coast Guard activities. For example, if ships are equipped with systems to periodically report location, it will be possible to continuously track the location of any ship anywhere in the world.[35] Such systems could be used in conjunction with Vessel Traffic Services (VTS) or as part of the AMVER system to automatically update ship positions. Note that it would be possible to place covert communications devices that could provide geolocation information in small packages unlikely to be detected.

GPS dominates navigation

Discussion

Maritime users have a variety of radionavigation requirements, including for support of navigation, surveillance, and positioning. The requirements for accuracy and coverage vary considerably. Navigation services encompass a range of alternatives, from oceanic navi-

34. For example, the Skycell system developed by American Mobile Satellite Corp. extends coverage to an area only 200 miles from the U.S. coast. See, "SATCOM: The alternatives open up," *Marine Log*, July 1994, p. 22. The problems will grow in the future, as the demand for greater bandwidth grows. According to one estimate, a U.S. Navy flagship will require a bandwidth of 20 gigabits per second by 2015. U.S. Air Force Scientific Advisory Board, *New World Vistas*, May 1996, p. 24.

35. The Coast Guard is funding some exploratory research on this technology area.

gation, which requires accuracies of 1,800 meters or more) to inland waterways navigation, where 3-meter accuracies are needed. Surveillance is significant in the context of vessel traffic services that rely on cooperative reporting of ship location. Positioning, which supports research exploration and hydrographic surveying work, requires accuracies down to 0.05 meter. These alternative applications are shown in table 6.

Table 6. Requirements for maritime navigation[a]

	Application	Accuracy (2 drms)	Time to alarm	Coverage	Resistance to RF interference
Navigation	Oceanic	1,800–3,700 m (1–2 n.mi.)	Not specified	Global	Moderate
	Coastal	460 m (0.25 n.mi.)	Not specified	U.S. coasts	Moderate
	Harbor/harbor approach	8.0–20.0 m	6–10 sec	Harbors and approaches	High
	Inland waterway	3.0 m	6–10 sec	Inland waterways	High
	Recreational boating	10.0 m	Not specified	Coasts and inland waterways nationwide	Moderate
Surveillance	Vessel Traffic Services	10.0 m	Not specified	Local	Very high
Positioning	Research exploration	1.0–3.0 m	Not specified	Global	Moderate
	Hydrographic surveying	.05–10.0 m	Hours	Global	—

a. Source: National Research Council, *The Global Positioning System, A Shared National Asset: Recommendations for Technical Improvements and Enhancements* (Washington, DC: National Academy of Sciences, 1995), pp. 35, 45.

The Coast Guard currently has statutory responsibilities to provide maritime radionavigation support to the Department of Defense and civilian users. In addition, however, the systems it currently operates, LORAN–C and OMEGA, also support aircraft and other users. The Coast Guard continues to operate LORAN–C transmitters within the territory of the United States. Until recently, it also operated

LORAN–C transmitters in foreign countries as a service for the Department of Defense. Under current plans, LORAN–C is scheduled to be phased out in 2000. The Coast Guard still operates OMEGA systems, primarily as a service to NOAA (which uses it with weather balloons), the aviation industry, and the U.S. Navy (which used it for operations beneath the polar ice cap). Under current plans, U.S. operation of OMEGA will terminate on 30 September 1997, and has been dropped from the budget for 1998. Table 7 outlines various radionavigation systems in which the Coast Guard is involved.

Table 7. Radionavigation systems

	Accuracy (2 drms)	Area of coverage
OMEGA	2.0–4.0 n.mi.	Worldwide
LORAN–C	0.25 n.mi.	Regional (continental U.S. and adjacent waters)
GPS–selective availability	100 m	Worldwide
Local area differential GPS	3 m	Regional

The role of the Coast Guard in providing radionavigation services has been transformed by the arrival of satellite navigation services, which are revolutionizing navigation and positioning services. The NAVSTAR Global Positioning System (GPS) developed by the U.S. Department of Defense relies on a constellation of satellites to provide location information accurate to 100 meters for non-military users. The Department of Defense deliberately degrades the quality of the signal for non-DOD authorized users through a policy known as selective availability. Without selective availability, GPS can provide civilian users with accuracies of 30 meters (or better, under the right circumstances). GPS provides accuracy of 16 meters for military users, although in practice the accuracy is often significantly better.

Suggestions for upgrading the system, which is based on 1970s technology, indicate that it will be possible to further enhance the accu-

racy of the system. According to one estimate, even without adoption of augmentation systems, it should be possible to improve GPS accuracy to better than 5 meters.[36]

The accuracy of GPS can be enhanced through what is known as differential GPS (dGPS). Maritime use of GPS is being enhanced by the USCG's dGPS system, a supplement that enhances accuracy for all receivers equipped to read the USCG dGPS transmissions. Tests indicate accuracies of 3 meters in covered areas along the U.S. coast and inland waterways.[37]

Besides the USCG dGPS system, there are alternative suppliers of differential GPS services.[38] At least eight other federal agencies operate differential GPS base stations, including the Corps of Engineers, NOAA, the St. Lawrence Seaway Development Corporation, the U.S. Geological Survey, the Bureau of Land Management, the Forest Service, and the FAA.[39] Other countries also provide differential services

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36. National Research Council, *The Global Positioning System, A Shared National Asset: Recommendations for Technical Improvements and Enhancements* (Washington, DC: National Academy of Sciences, 1995), pp. 180–200.

37. A description of the new system appears in CDR Douglas H. Alsip, LCDR Jean M. Butler, and James T. Radice, "U.S. Coast Guard Differential GPS Network," *Sea Technology*, March 1993, pp. 60–66. Different sources offer varying estimates of the accuracy of the Coast Guard's differential GPS system. The Coast Guard claims ±10 meters, whereas the National Research Council puts the figure at 3 meters. The difference between these two figures is more apparent than real. The ±10 meter figure covers "all specified coverage areas," whereas the 3 meter figure involves users with a high-end receiver within 300 kilometers of the transmitter. See the paper by LCDR Gene W. Hall, "USCG Differential GPS Navigation Service," Coast Guard web site, no date, p. 3.

38. By law, the Coast Guard is the only organization that can provide radionavigation services for maritime navigation. See Scott Pace et al., *The Global Positioning System: Assessing National Policies* (Santa Monica, CA: Critical Technologies Institute, RAND, 1995), pp. 177–178.

39. General Accounting Office, *Global Positioning Technology: Opportunities for Greater Federal Agency Joint Development and Use*, GAO/RCED–94–280 (Washington, DC: U.S. Government Printing Office, September 1994).

to mariners, and there are commercial providers in the United States as well. Differential stations are relatively inexpensive and easy to put into operation; as a result, the total number of dGPS stations in operation can vary from day to day, and the actual number in service worldwide is not known. In addition, there are proposals to develop wide-area augmentation systems—which would provide global differential coverage—by the FAA (to support aviation requirements) and INMARSAT. The FAA system—which is expected to enter service in 2001—would support Category I precision approaches, which requires an accuracy of at least 7.6 meters.[40]

Although originally developed for military purposes, it appears that the pressures for civilian use of the technology will lead DOD to make available the highest levels of accuracy to non-DOD users. The availability of increasingly small and inexpensive GPS chip sets will make satellite navigation systems ubiquitous. They are now small enough to fit in cigarette-box-sized containers. Within a few years, they will fit in enclosures the size of a wrist watch. It is likely that GPS sets will be small and inexpensive enough to be embedded into a variety of types of equipment, including cellular telephones and radios.

Currently, the number of non-military users far exceeds the number of military users, and the gap will continue to grow in the future. These systems have found widespread acceptance in the commercial maritime community and among recreational boaters. According to one estimate, there could be more than 11 million GPS sets in use in the United States by 2003—most would be in automobiles, but nearly 1 million would be in maritime use.[41]

Implications for Coast Guard

GPS is already making itself felt on many aspects of Coast Guard activity. According to one estimate, use of GPS has reduced the time required to lay buoys by one-third, yet enhances the accurate posi-

40. National Research Council, *The Global Positioning System,* pp. 27–29.

41. Based on a Booz Allen & Hamilton study prepared for the National Research Council, as reported in National Research Council, *The Global Positioning System, A Shared National Asset.*

tioning of the buoys.[42] The greater navigational accuracy made possible with differential is considered an essential element of the new electronic charting systems using digital charts (discussed in more detail in the next section). GPS data also are an important input to Automated Dependent Surveillance (ADS), which involves a ship reporting its location using GPS data as part of a VTS system.[43]

Currently, the Coast Guard plays an important role in the maritime use of GPS through its differential GPS system. As shown in table 6, maritime users have a requirement for accuracy down to 3 meters. It does not appear that it will be possible to obtain such levels of accuracy using GPS by itself. Even with system improvements, it is unlikely that GPS will be able to provide accuracies of better than 4 to 5 meters. Only through use of some kind of augmentation system, such as the Coast Guard's dGPS, will it be possible to obtain those levels of accuracy. This is not expected to change in the foreseeable future. Accordingly, it appears that until alternative augmentation systems appear, there will be a need for the Coast Guard differential GPS system.

The appearance of wide-area differential systems, such as the FAA's proposed satellite-based system, could erode the need for Coast Guard provided services. Accordingly, it is possible that the need for Coast Guard provided radionavigation services could be eroded, when combined with proposed enhancements to basic GPS services.

Integrated navigation systems become standard

Discussion

The maritime community is now beginning a transition from paper to electronic charts. The importance of this transition, however, is not in the charts themselves. Rather, the development of electronic display and information systems (ECDIS) is expected to have a revolu-

42. "Saving Coast Guard Time, Money with GPS Technology," *Sea Technology*, June 1995, p. 70.

43. Adm. Robert E. Kramek, "Coast Guard: Leveraging Technology for Quality Service at Less Cost," *Sea Technology*, January 1996, p. 24.

tionary impact on ship navigation, at least as significant as the introduction of radar. These systems integrate charts with DGPS signals to produce accurate plots of ship location, and will become part of new integrated navigation systems (INS), also called integrated bridges. Such systems integrate all ship sensors, including radar, gyrocompass, and speed log, and also permit voyage optimization and heavy weather damage prevention systems.[44] INS will provide mariners with enhanced situational awareness. Some believe that ECDIS will become a requirement under the Safety of Life at Sea (SOLAS) convention.[45]

The core of the new INS capabilities is electronic charting. The adoption of ECDIS is expected to expand with the development of standards by the International Maritime Organization (IMO), the International Hydrographic Organization (IHO), and the International Electrotechnical Commission (IEC). The IMO is responsible for the general performance specifications, the IHO is responsible for defining data formats, and the IEC sets physical standards. In addition, the Radio Technical Commission for Maritime Services (RTCM) in the United States is developing additional standards for simpler electronic charting systems more suitable for use by smaller commercial craft and by recreational boaters.[46]

ECDIS is enabling the creation of INS that will access data from external sources needed to improve the quality of navigation. Thus, it is now possible to integrate radar images into chart displays, and eventually it will be possible to provide other critical information as well, such as the location of icebergs, vessel traffic control information, and real-time tidal information. ECDIS standards require a capability to incrementally update charts as modifications are introduced by hydrographic agencies.

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44. "Integrated navigation systems: putting it all together on the bridge," *Marine Log*, October 1995, pp. 31–34.

45. Dave Dooling, "Navigating close to shore," IEEE *Spectrum*, December 1994, p. 31, citing Dr. Lee Alexander of the Coast Guard's R&D Center.

46. Lee Alexander and Frederick K. Ganjon, "ECDIS: Current Status, Future Expectations," *Sea Technology*, March 1995, p. 11.

By carefully integrating the new INS capabilities into ship bridges, it has become possible to produce one-person watchkeeping. The Norwegian standards society, Det Norske Veritas, has created a W–1 class notation to certify ships with integrated bridges approved for one-person operation.[47]

The most significant problems in the development of automated navigation systems are human factors concerns, which are a primary focus of the Det Norske Veritas W–1 certification. Filtering of data in the digital systems must not create an inaccurate or incomplete picture. The systems must generate appropriate alarms to warn of unusual situations, including equipment not operating correctly. Finally, the components of the systems must be put together in ways that do not create risks of human error.[48]

For some mariners, INS is seen as a cost-saving tool that will permit reduction in the number of people needed to operate a ship. Other operators, however, are focused more on safety and efficiency. Operators of tankers carrying petroleum products view INS as a way to reduce chances of an accident leading to an oil spill. Operators of container ships view voyage-optimization software as an important tool in reducing time at sea and thus reducing operating costs.

Some in the shipbuilding industry believe that eventually it will be possible to develop ships that rely on completely automated navigation systems requiring no human intervention. Indeed, they believe it will be possible to operate ships from dock to dock with no direct human intervention.[49]

At present, the inadequacy of existing charts poses a serious limitation to the adoption of ECDIS and INS.[50] It is estimated that there are defined quality-control standards for fewer than half of the 7,000 nau-

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47. "Making W-1 approval simpler to obtain," *Marine Log*, October 1995, p. 31.

48. "Integrated navigation systems," *Marine Log*.

49. Japanese companies, backed by MITI, are working on such systems now. "Integrating systems on the bridge," IEEE *Spectrum*, December 1994, p. 30.

tical charts now in world wide use. About 60 percent of U.S. waters were surveyed before 1940, and about 75 percent of British waters were surveyed more than 100 years ago. Relatively few charts are based on modern survey techniques. As a result, it is possible for charts to display objects in locations different from those calculated by GPS.[51] This is not significant in ocean navigating, but it is critical in restricted waterways.[52]

To resolve these problems, the National Ocean Survey of the National Oceanic and Atmospherics Administration (NOAA) has adopted a plan to give priority to the most important areas, including areas around ports with the highest volume or value of trade and areas used by cruise ships. This will involve using aerial photographs to resurvey shorelines supported by new soundings in critical areas. NOAA is trying to reduce the time required to produce new charts based on survey data from two to three years to only eight months.[53]

The NOAA plan will not produce the kinds of charts commonly thought necessary to support electronic navigation. Some industry figures, however, believe that these problems are overstated. They note that the primary navigation channels used by commercial mariners are well charted, covering most high-priority water.[54]

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50. A review of deficiencies in U.S. nautical charts is contained in National Research Council, *Charting a Course into the Digital Era: Guidance for NOAA's Nautical Charting Mission* (Washington, DC: National Research Council Press, 1994).

51. Dave Dooling, "Digitizing charts for mariners," IEEE *Spectrum,* December 1994, p. 26.

52. Currently, GPS systems can display ship locations incorrectly. The problem may be faulty GPS readings. It also could be that the charts use different baselines from those of GPS. Until the two systems are fully synchronized, such discrepancies will impede reliance on GPS in restricted waterways.

53. Tim Queeney, "Charting plan focuses on commercial areas," *Ocean Navigation,* Jul/August 1996, pp. 16–19.

54. Dr. Fosco Bianchetti, "Impact of New ECDIS Standards On the Electronic Chart Industry," *Sea Technology,* March 1995, pp. 26–27.

Even if the charts are accurate, however, they must be available in formats suitable for use in digital charting systems. IMO and IHO standards call for vector-based charts, supplied by an internationally recognized hydrographic office. Such charts are in limited supply. NOAA, for example, currently only provides raster versions of its charts.

The improved accuracy possible with GPS has added new requirements for charts with levels of detail never previously needed. Differential GPS is accurate enough to permit docking even in conditions of poor visibility. Unfortunately, current charts do not possess the level of needed detail. NOAA is exploring use of Corps of Engineers harbor surveys to provide large-scale charts for docking.[55]

Implications for the Coast Guard

The development of integrated bridge systems, coupled with ECDIS and GPS, is likely to have a profound impact on the maritime industry. This technology will become an essential component of all ship operations, and will be adopted by the Coast Guard. In addition, Coast Guard safety personnel will need to become familiar with these new technologies in order to conduct ship inspections.

The spread of INS capabilities is likely to profoundly affect vessel traffic services and ship positioning systems. Using this technology, it should be possible for ships to automatically generate positioning data that can be provided to ship owners. Such data could be useful to the Coast Guard for traffic services and as part of the AMVERS system.

INS capabilities also have profound implications for aids to navigation. Once INS and ECDIS-type systems achieve widespread use, the requirement for ATON is likely to diminish significantly. The need for ATON may not disappear, however, even with widespread adoption of electronic charting by recreational boaters, since there will remain a need for some back-up capabilities to supplement the electronic systems. However, the number of aids will decline, perhaps sig-

55. Alexander and Ganjon, "ECDIS: Current Status, Future Expectations," *Sea Technology*, March 1995, p. 16.

nificantly, and the resources required to support them also will decline.

Satellite surveillance is more accessible

Rapid strides in satellite surveillance technology are likely to substantially enhance the kinds of information obtained from space-based systems. Some of the improvements result from developments in the commercial arena. Commercially available electro-optical systems likely to be widely available in the early 21st century will provide 1-meter resolution (perhaps less). Such improvements in technology will make possible constellations of satellites capable of continuous, or near continuous, coverage of large areas at relatively low prices. Also RADARSATs and other systems will be increasingly available.

Here's an example of where the technology is progressing: the U.S. Air Force Scientific Advisory Board conducted a study that called for the deployment of a distributed constellation of small satellites providing continuous global surveillance.[56] This system would provide the following capabilities:

1. Continuous multi-spectral observation at 10-meter resolution with 2–3 meter targeting
2. Continuous location and targeting of radio frequency (RF) emitters to 10 meters
3. Synthetic aperture radars with 1-meter resolution once per hour
4. Sub-meter resolution once per day, multispectral and radar.

In addition, the Air Force calculates that if it is possible to operate aerial platforms within 200–300 n.mi. of a region, it will be possible to provide continuous multispectral and radar observation at 1-meter resolution. By comparison, if it is possible to overfly the area of interest, it will be possible to provide continuous multispectral and radar observation at 1-centimeter resolution.

56. U.S. Air Force, *New World Vistas,* 15 December 1995, pp. 20–22.

In addition, the Air Force anticipates that satellites and unmanned aircraft will carry laser sensors capable of detecting chemical weapons by detecting the presence of trace quantities of chemicals associated with chemical agents.

For some time, efforts have been made to track ship movements by using satellite data. The Canadian RADARSAT system is now providing an opportunity to develop synthetic aperture radar inputs that could be used to track ship movements.[57] Experiments by Lincoln Labs indicate that it is possible to do automated ship identification with the same accuracy as that of humans. This is done by using neural networks to analyze the inputs from multiple sensors.[58] Experiments suggest that satellite data can be used to track ice movements.[59]

Current U.S. government estimates suggest that by 2010 the Coast Guard will have routine access to spaceborne synthetic aperture radar information.[60]

Implications for the Coast Guard

Satellite surveillance could give the Coast Guard an instant ability to generate data on some particular area of interest. In theory, this would allow the Coast Guard to track activities of interest over an extended period of time (such as tracking the movement of a particular ship). Similarly, the systems should make it possible to monitor ice using remote sensors.

Several issues arise from the presumed availability of such systems. First, will systems actually built be suitable for the requirements of the

57. Gordon C. Staples, David Martenson, and Dennis Nazarenko, "High Seas Ship Surveillance View RADARSAT," *Sea Technology*, November 1995, pp. 59–62.

58. U.S. Air Force, *New World Vistas*, May 1996, p. 60.

59. Dr. Frank Carsey, "Charting Movement of Sea Ice by Satellite," *Sea Technology*, October 1995, pp. 17–22.

60. Interagency Committee for Search and Rescue (ICSAR) Working Group, "SAR Vision 2010," 30 April 1996.

Coast Guard? There may be specific characteristics that would enhance the utility of the systems for Coast Guard functions, which might be incorporated if those responsible for designing such systems were aware of Coast Guard requirements.

Second, the systems will generate considerable quantities of data, which will have to be processed in order to provide useful information. The ability of the Coast Guard to address such problems will be affected by growth in computer capabilities, and by AI and computer software improvements. The result will be an ability to integrate disparate data inputs into a coherent picture (a process known as "data fusion"). The Coast Guard will need to address data fusion problems similar to those that DOD currently is attempting to solve.

Despite dropping costs, satellite surveillance systems will remain too expensive for the Coast Guard to operate its own systems. Accordingly, the Coast Guard will need to rely on systems built and operated by other providers (such as the Department of Defense, civilian government agencies, or private companies).

Sensors become ubiquitous

Using sensors based on land, ships, or aircraft, it will be possible to develop new sources of information. In some cases, the availability of this information may result from the ability to deploy remote sensors capable of inexpensively communicating information to distant locations. Thus, new communications systems may make it possible to deploy cameras and other sensors on fishing vessels to generate data for transmission to remote monitoring stations. Such systems could supplement current on-board inspections.

Some data essential to safe navigation cannot adequately be reported using traditional navigation charts and data. Thus, tides vary depending on weather conditions, and as a result water depth can diverge from published tide tables. For this reason, NOAA has developed the Physical Oceanographic Real Time System (PORTS) for monitoring hydrographic and weather data for major commercial harbors. The system is currently installed at the ports of Houston, New York, San Francisco, and Tampa.[61] PORTS includes acoustic Doppler current

profilers (ADCPs) to track water movements, and other instruments to measure wind direction and speed and water level and temperature. The sensors are linked to provide continuous real-time, publicly accessible reporting.

Implications for the Coast Guard

Improved sensors will affect most Coast Guard activities. First, it will be possible to place sensors of various kinds on Coast Guard systems to remotely monitor system health. Inexpensive sensors on aids to navigation could warn if a buoy has moved from its designated position. Sensors on lighthouses could detect failures in performance of systems. Second, various monitoring tasks could be enhanced. Thus, the task of placing sensors around areas of concern could be made easier by the availability of low-cost sensors. Third, inspection of ships could be eased by the development of improved sensors that are built into ships or are carried by inspectors and that could monitor the structural health of the ship.

Remotely piloted air vehicles replace many fixed-wing aircraft

Use of unmanned air vehicles (UAVs) has grown substantially over time. Currently, the U.S. military and intelligence communities are developing and acquiring a growing array of surveillance systems. Improvements in core technology (engines, airframe materials, electronics), coupled with technology enhancements that make possible smaller and lighter surveillance packages requiring less power, have enabled the national security community to develop relatively inexpensive, high-capability systems. Indeed, advances in technology have led some in the USAF technical community to believe that it will be possible by 2020 to produce unmanned aircraft capable of replacing the fighter aircraft.[62]

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61. The New York system is currently not in operation, due to NOAA budget constraints; it will only enter service when a local source of financing emerges.

Some of the more interesting technologies from the perspective of the Coast Guard are related to the development of high-altitude, long-endurance (HALE) platforms. For example, currently the Defense Advanced Research Projects Agency is developing a new high-altitude, long-endurance remotely piloted vehicle (RPV), costing no more than $10 million per vehicle, capable of operating for extended periods of time. In addition, improvements in communication (high-bandwidth digital transmission of compressed data being a key enabling technology) and sensor technologies also make such systems more viable. Technology trends suggest that such systems will continue to decline in cost and grow in capability.

The U.S. Air Force Scientific Advisory Board postulates that it will be possible to produce HALE unmanned aircraft within 20 years. Such an aircraft could carry a 2,000-lb payload, fly at low subsonic speeds, operate at above 80,000 feet, and operate essentially indefinitely. The HALE system would rely on an electric motor, possibly using solar energy to recharge batteries. Although some technological breakthroughs would be needed to make possible such a system, including the motor, adaptive materials for the structure, and improved energy storage systems, the board foresees no insurmountable barriers to the development of such systems.[63]

In addition, the Air Force believes that it will be possible to build extremely small aerial platforms, which it refers to as "microairvehicles." It will be possible to place sensors on those minidrones that can supplement the data collected from those operating in space or at higher altitudes.[64]

Interestingly enough, the Air Force also believes that the early years of the 21st century could see a revolution in seaplane design: "advances in hydrodynamics leading to new hull and float designs

62. U.S. Air Force Scientific Advisory Board, *New World Vistas*, May 1996, pp. v–xx.

63. Ibid., pp. 18–24.

64. Ibid., p. 14.

promise to enable a renaissance of new seaplanes."[65] Seaplanes could operate in weather up to sea state 3.

Implications for the Coast Guard

Conceptually, it is possible that Coast Guard could use RPVs for activities requiring surveillance and reconnaissance, such as ice patrols, search and rescue, or law enforcement. It is possible that the systems could be inexpensive enough to permit widespread access to microairvehicles, and that there would be fewer HALE-type systems. In addition, the Coast Guard might find seaplanes or tilt-wing vertical-take-off aircraft attractive for missions now conducted using helicopters.

Revolutionary advances are made in materials/devices

It is possible that the next few decades could see a revolution in materials. We could see the widespread use of new materials that are stronger, are lighter, are capable of operating at higher temperatures, and have some built-in intelligence.

In part, the improvements will result from the use of increased computer capabilities to design—at the molecular level—materials. This will be facilitated by so-called desktop manufacturing, which will make it possible to manufacture materials atom by atom to optimize for particular characteristics.

Microelectromechanical machines (MEMs) will integrate computers with microscopic machines. Such devices already exist: the most widely used types are the sensors that activate automobile air bags. In the future MEMs will be ubiquitous. Future aircraft could be built with surfaces containing MEMs with microscopic flaps or air holes that would allow them to modify the flow of air over the surface of the aircraft and significantly reduce turbulence. This is a key enabling technology for improved sensors, which will be built into structures to provide continuous monitoring of structural health.

65. Ibid., p. 28.

Improved superconducting materials will enter commercial service. Experimental devices intended to enhance the efficiency of electrical transmission and consumption are now being developed, including electric motors using high-temperature superconductors. It is unlikely, however, that we will see long-distance power transmission using such materials, if only because it will be more efficient to move the original energy source than to generate power in remote locations.

Adaptive materials

By 2020 we will be able to produce intelligent materials capable of reacting to changing conditions. They rely on built-in actuators that alter basic physical properties in response to changes in the environment, sensors that monitor physical status, and embedded computational devices. Such materials will contain embedded sensors and computers, and will be capable of changing properties.[66]

Marine vehicles change in size and speed

Several trends are evident in the ship-building industry. Tanker design is dominated by safety and environmental considerations as the industry seeks to comply with OPA 90 requirements.

Container ships are now larger. Some ships are now capable of carrying 6,000 teu (20-foot equivalent units), and larger ships are expected. More speculatively, it is possible that by the turn of the century we will see the development of substantially faster ships, including container ships and car transports capable of speeds of up to 40 knots. Advocates of the Fastship, for example, believe that on trans-Atlantic runs a fleet of eight container ships capable of 35 knots can replace up to 35 standard container ships.

Finally, as the efficiency of maritime transport grows, the economic weight of the ship costs in overall transportation is declining. As a result, the shipping industry is increasingly concerned about the link-

66. Ibid., p. 50.

ages between modes of transport. Thus, the adequacy of rail and road links at U.S. ports has become a higher priority.

Our discussion of economic trends also touches upon the changes in the size and speed of marine vehicles.

Integrated maritime information system emerges

It is generally recognized that improvements in information technology are profoundly affecting modern life. In particular, the growing capabilities of computers and communications systems have had a pervasive impact on the global economy and society. These technologies, along with sensor technologies—including satellite observation—that have enhanced our ability to monitor the environment, are also having an effect on the maritime world.

In reviewing the trends already presented, it becomes increasingly clear that we are in the beginning stages of creating information systems that are affecting the entire maritime environment. This industry is emerging largely from the commercial sector, which views information technology as a means to reduce costs, speed delivery times, and improve safety. Some of the components of these systems, however, will need to come from the public sector, and many aspects of this new information infrastructure will affect the Coast Guard.

These systems will involve most participants in the maritime arena, including commercial interests—both shippers and shipping companies; pleasure boaters; and those who support users of navigable waters, such as NOAA, the Corps of Engineers, the Customs, Immigration and Naturalization Service, and other U.S. and foreign government agencies. Thus, future communications systems will allow the mariner to acquire updated charts, monitor environmental conditions (waves, currents, water depth) in real-time, continuously track the location of other ships, and provide customers with precise estimates of delivery time.

Many of these things are going to be done because it makes economic sense to do them, and the maritime industry is moving in those directions. Only some of the systems under development or entering ser-

vice directly involve the Coast Guard; these include VTS and dGPS. However, the Coast Guard has an interest in many of the systems, either because it will be a user (as with digital charting), or because it will play a role in setting standards and in monitoring compliance with standards (which was a key role played by the Coast Guard in setting up its dGPS service).

The emergence of this system will open interesting opportunities and challenges for the Coast Guard. First, it can create new ways of conducting traditional operations. Second, it will make existing systems seem redundant or useless.

Both conditions are applicable when considering the future of a Coast Guard capability such as AMVER. AMVER may be duplicative in a world where all merchant ships are required to have identifying transponders aboard that emit continuous ship position data. At that point it would be possible to generate a global ship data base that would support maritime rescue operations, among many other possible functions.

In addition, it appears likely that the role of setting standards in the new environment will be increasingly important. Just as it was necessary to define a standard signal for the Coast Guard's dGPS service, it will be necessary to do so in a host of maritime applications to ensure that the applications using certain capabilities are developed to the extent possible and desirable. This is clearly an issue in the case of integrated navigation systems, since standards for chart data bases need to be supportable by those generating the original data. But if past and current experience is any guide, this issue may arise again and again. In the past, the Coast Guard has facilitated information technologies such as dGPS by taking the lead in applying it to the maritime environment. It will have many future opportunities to do so.

Political trends

Coast Guard-relevant political trends include the following:

- Law of the Sea (LOS) is increasingly accepted.
- Piracy declines.
- CG contributions to defense increase.
- U.S. surface combatant force evolves.

Law of the Sea (LOS) is increasingly accepted

The offshore regime

Territorial sea

Under contemporary international law, every coastal state has the right to establish a breadth of offshore waters in the form of a territorial sea not exceeding 12 nautical miles, measured from the low-tide mark along the coastline. Subject to the right of innocent passage, the coastal state enjoys the same sovereignty over its territorial sea, and the air space, seabed, and subsoil thereof, as it has with respect to its land territory. As of August 1996, 137 states, including the United States, have declared such a 12-n.mi. territorial sea.

The contiguous zone

In a zone contiguous to the territorial sea, the coastal state may exercise the control necessary to prevent infringement of its customs, fiscal, immigration, or sanitary laws and regulations within its territory or territorial sea.[67] A U.S. customs officer may board any vessel within U.S. customs waters to examine its manifest and inspect and search it, irrespective of whether it is bound for the United States.[68] Violation of United States law renders the vessel subject to arrest and seizure.[69]

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67. 1982 Law of the Sea Convention, Article 33.

Exclusive economic zone

Pressures for increasing the jurisdiction of coastal states over waters adjacent to the territorial sea grew from demands during the 1970s for better conservation and management of coastal fisheries. Although increased exploitation of fisheries in waters contiguous to the coast had prompted some states to enact unilateral fishery conservation zones during the 1970s, it was the Third United Nations Conference on the Law of the Sea that developed the concept of such a special 200-mile zone. Accordingly, the 1982 LOS Convention established a 200-mile exclusive economic zone (EEZ) in which a coastal state has sovereign rights for the purpose of exploring, exploiting, conserving and managing all living resources therein.[70]

The coastal state also retains rights in its EEZ with respect to nonliving resources of the seabed, subsoil, and superjacent waters, and other activities undertaken for economic exploration and exploitation of the zone, such as the production of energy from the water, currents, and winds.[71] Within the EEZ, a coastal state has limited jurisdiction over the establishment and use of artificial islands, installations, and structures; marine scientific research; and the protection and preservation of the marine environment.[72]

Within an EEZ, all states may exercise the high-seas freedoms of navigation and overflight and of laying submarine cables and pipelines. Note well, however, that the traditional high-seas freedom to fish is specifically and intentionally withheld from states within the EEZ of some other state. Only the coastal state can grant permission to vessels of other states to fish within the former's EEZ. In exercising these freedoms, all states must give due regard to the rights and duties of

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68. 19 USC section 1581.

69. Ibid.

70. 1982 LOS Convention, Articles 55-75.

71. 1982 LOS Convention, Article 56.

72. 1982 LOS Convention, Articles 56 and 60, and Parts XII and XIII generally.

the coastal state and shall comply with the lawful rules and regulations of the coastal state. [73]

Future trends

Assertion of coastal state jurisdictional rights and obligations during the 1960s and 1970s became widely characterized by the so-called phenomenon of "creeping jurisdiction," i.e., the tendency of coastal states to claim increasingly broad expanses of ocean space offshore as designated areas under their national jurisdiction. The territorial sea, traditionally accepted under customary law at 3 n.mi., became subject to various and irregular national claims by various governments, ranging from the traditional 3 n.mi. limit (by the United States and Great Britain) to 200 miles (e.g., Chile, Ecuador, Peru, and Panama). The Third Conference on the Law of the Sea standardized the breadth for coastal state offshore jurisdiction by fixing the territorial sea at12 n.mi., the contiguous zone at 24 n.mi., and a new jurisdictional area, the exclusive economic zone, at 200 n.mi. from the coastal baseline of a state. The predominant trend since 1990, especially since entry into force of the 1982 LOS Convention in November 1994, has been the unmistakable willingness of coastal states to adopt these various offshore zones.

As additional governments continue to ratify the 1982 LOS Convention, the most likely trend for the foreseeable future suggests continuation of national governments accepting these standardized breadths seaward. Unless the 1982 LOS Convention were to collapse for some reason unforeseeable at this time, the prevailing likelihood is that the 12-mile territorial sea, 24-mile contiguous zone, and 200-mile exclusive economic zone will continue to be accepted and observed by coastal states with few exceptions in 2020. The presumed rationale for this conclusion is clear: Such standardized breadths demarcating offshore zones are manageable, practicable, and enforceable, and well serve the security and resource national interests of all coastal states. A distance of 200 n.mi. seaward ensures that coastal states have access to at least 90 percent of living marine

73. 1982 LOS Convention, Article 58.

resources and some 95 percent of estimated offshore petroleum and natural gas reserves on continental shelves.

Piracy declines

The law

Piracy, defined as any illegal act of violence, detention, or depredation committed for private ends by the crew of one ship against the persons or property of another ship on the high seas beyond the jurisdiction of any state, is a violation of the law of nations.[74] International law clearly and unequivocally asserts the duty of governments to cooperate in the repression of piracy: "All States shall co-operate to the fullest extent possible in the repression of piracy on the high seas or in any other place outside the jurisdiction of any State."[75] To that end, a ship engaged in piracy on the high seas may be seized and the persons arrested by any state, granted under the legal principle of universal jurisdiction.[76] Where provided for by treaty, a suspect pirate vessel registered in one state may be boarded, searched, and seized by a government ship of a foreign state as a cooperative measure for the prevention of piracy. The pirate vessel and its prisoners are supposed to be taken to the nearest appropriate court of the arresting state, where that court decides on the penalties to be imposed and the disposition of the craft and its contents (again, under the recognized legal principle of universal jurisdiction).

A pirate ship retains the nationality of the state in which it is registered, unless the national laws of that state view piracy as grounds for loss of nationality. In such a case, the ship would be regarded by all governments as stateless.

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74. 1982 LOS Convention, Article 101.

75. 1982 LOS Convention, Article 100.

76. 1982 LOS Convention, Article 105.

The policy problem

Modern pirate attacks have occurred with irregular frequency off the western coast of Thailand, in the Gulf of Thailand, the Sulu Sea, the Java Sea, and the Celebres Sea, as well as along the western coast of Africa.[77] Most recent pirate attacks have been directed at so-called boat people or refugees in the South China Sea and in the Gulf of Thailand. It is believed that since 1980, pirates have killed more than 2,000 boat people and have abducted hundreds of young women to be sold to brothels in Thailand and elsewhere on the South Asian mainland. In 1981, in the Gulf of Thailand, 1,444 attacks on refugee boats were reported. Reports state that of 71,667 people fleeing Vietnam that year, 961 were killed, 257 were taken hostage, and 857 women were raped by pirates. As late as 1989, 762 Vietnamese or Cambodian refugees were reported killed or missing at sea, presumably at the hands of pirates.

Not all recent attacks by pirates have been aimed at small crafts containing boat people, however. During the 1980s, dozens of attacks came against merchant ships sailing along the west coast of Africa, in the South China Sea, and on rare occasions, in the Caribbean. These attacks against merchant ships have varied over the past 15 years, from a reported 74 incidents in 1983, to some 523 between 1989 and 1993. Half these attacks came in Southeast Asia, and at least 21 of those ships carried U.S. registry.[78] Since 1993, however, such attacks against commercial shipping in the Strait of Malacca have noticeably diminished since Indonesia, Malaysia, and Singapore concluded bilateral agreements permitting pursuit of pirates by their respective navies. Relatedly, the United Nations High Commissioner for Refugees phased out its eight-year anti-piracy program at the end of 1991 because no new incidents had been reported in 1990.[79]

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77. See *The Washington Post*, Sept. 2, 1980, *Time*, Nov. 9, 1981; *The Boston Globe*, May 9, 1993, p. 5.

78. "Today's Pirates Pose Double Trouble," *Parade Magazine*, in *The Washington Post*, April 13, 1994, p. 16.

79. *The New York Times*, January 1, 1992, p. 7.

Acts of piracy against U.S. vessels or citizens are specifically outlawed and made punishable under the U.S. Code.[80] In dealing with international law toward piracy, the U.S. Coast Guard could be called upon by the executive branch to assist in the enforcement of that law on the high seas.[81] If U.S.-registered vessels, or even foreign shipping, were attacked by pirates, U.S. Coast Guard vessels could participate in efforts to rescue those vessels or apprehend those pirates, either on the high seas, or in another state's territorial waters (with express permission of that government), or in U.S waters. Such efforts would clearly fall under the rescue-at-sea efforts sponsored by the UN High Commissioner for Refugees for victims of such attacks.

Future trends

Statistical information relating to pirate attacks is notoriously unreliable and incomplete. Although compiled by competent and reliable sources—e.g., the U.N. High Commissioner for Refugees, the International Maritime Organization, the International Chamber of Commerce's International Maritime Bureau, and shipowners—most data are derived from refugee reports, which are often sketchy, vague, and confused. Moreover, many attacks undoubtedly go unreported. Accurately assessing trends for acts of piracy is therefore made all the more difficult.

It is reasonable in any case to assume that pirate attacks will continue, although they will remain particularly localized to waters around Southeast Asia, and to a lesser degree, offshore western Africa. Based on trends during the 1990s, the waters most susceptible to pirates in 2020 will be around Southeast Asia—principally those in the Malacca Straits area, including the strait itself, the Singapore Strait, and Phillip Channel. Also notably dangerous due to pirate attacks against refugee boats and merchant container ships (albeit less so) will be the waters off western Africa, stretching in the north from Dakar (Senegal) to Matadi (Zaire) in the south, and including Conaky (Guinea), Freetown (Sierra Leone), Monrovia (Liberia), Abidhjan (Cote D'Ivo-

80. 18 USC section 1651, 1994.

81. 33 USC section 383, 1994.

ire), Takoradi (Ghana), Lagos (Nigeria), Port Harcourt (Nigeria), and Douala (Cameroon).

Piracy, like all forms of crime, flourishes during times of disorder. Such disorder may result from war, civil strife, or a breakdown of law enforcement. In coastal regions offshore South Asia and western Africa, when domestic order breaks down, civil strife erupts, or economic conditions become desperate, persons who flee to the sea will continue to put themselves at risk of pirate attacks. Similarly, attacks by pirates against commercial vessels will undoubtedly continue to occur in those areas in some numbers. Present trends suggest that the frequency of these pirate attacks is more likely to diminish than to intensify in coming years.

CG contributions to defense increase U.S. surface combatant force evolves

This section discusses national defense related trends that could affect future requirements for Coast Guard resources.[82] The following discussion is not based on current strategy documents, such as the National Security Strategy, the National Military Strategy, the Defense Planning, or U.S. Navy guidance documents (such as *From the Sea* and *Forward From the Sea).*[83] This is because current authoritative statements may or may not reflect the views of future leaders, who will face different circumstances from those of today. Given the timeframe for this study (2020), we tried to disentangle current national strategy from the underlying principles that we believe will continue to guide our national strategy.

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82. This analysis, *inter alia,* draws on CNA Research Memorandum 96–90, *Future Coast Guard Cutter Study: National Defense Requirements,* August 1996, by Richard D. Kohout with CAPT Patrick H. Roth, USN (Ret.), and CNA Annotated Briefing 96-55, *Future Coast Guard Study: Briefing for the NAVGARD Board (Preliminary Results),* May 1996, by O. Kim Malmin.

83. In addition, we examined some classified literature, but did not rely on it for the following analysis.

Equally important, there is considerable disagreement about the likely future character of international relations and about what security challenges the United States may face. Accordingly, it makes no sense to characterize the likely requirement for Coast Guard capabilities either by examining the current security environment or by reference to current policy.

Analytic assumptions

For purposes of this study, we made certain assumptions about several key issues, including the likely national defense roles of the Coast Guard and the character of the international security environment.

Role of the Coast Guard

We assume that the defense roles of the Coast Guard as defined in law will not change appreciably, although future legislation may acknowledge the increasingly joint operation of military forces. Current law includes the Coast Guard as a military service and a branch of the armed forces of the United States (14 U.S. Code 1). In addition, current legal authority states that, "Upon the declaration of war or when the President directs, the Coast Guard shall operate as a service in the Navy" (14 U.S. Code 3). The Coast Guard operated as part of the U.S. Navy during both world wars, and operated with the U.S. Navy during other, more recent, undeclared wars.

Current military uses of the Coast Guard focus on its utility as an adjunct to the U.S. Navy. Department of Defense regulations (DoD Directive 5000.1) provide that during wartime the Coast Guard has three primary missions:

- To provide an integrated port security and coast defense force, in coordination with other Military Services, for the United States. [By law (14 U.S. Code 2), the Coast Guard is responsible for the Maritime Defense Zones in time of war.]
- To provide specialized Coast Guard units, including designated ships and aircraft, for overseas deployment required by naval component commanders.

- To organize and equip, in coordination with the other Military Services, and provide forces for maritime search and rescue, icebreaking, and servicing of maritime aids to navigation.

In addition, three annexes to the Memorandum of Agreement between the Department of Defense and the Department of Transportation further define specific national defense missions of the Coast Guard. These include maritime interception operations, environmental defense operations, and deployed port operations, security and defense.

During peacetime, the Coast Guard has two legally defined defense functions (14 U.S. Code 2). First, it must "develop, establish, maintain, and operate, with due regard to the requirements of national defense, aids to maritime navigation, ice-breaking facilities, and rescue facilities for the promotion of safety on, under, and over the high seas and waters subject to the jurisdiction of the United States." Second, it "shall maintain a state of readiness to function as a specialized service in the Navy in time of war."

Military capabilities of the Coast Guard

We also assume that the missions assigned to the Coast Guard will not cover the full range of naval missions. The growing sophistication and specialization of naval warfare, especially the requirement for ever more specialized and sophisticated systems to cope with high-intensity threat environments, limits the ability of naval component commanders to use Coast Guard assets interchangeably with naval units. At the same time, the Coast Guard clearly has capabilities, recognized by the U.S. Navy in the Memorandum of Agreement between the two services, that both complement and supplement those of the U.S. Navy. These capabilities, some unique, are necessary for the conduct of what is sometimes called Operations Other Than War (OOTWs). Although OOTW missions include some combat operations, they cover a range of missions that often emphasize traditional Coast Guard areas of expertise.[84] (These missions are categorized in table 8.) For example, OOTW missions include maritime interception

84. We have chosen to rely on the definition of OOTW that appears in CNA Research Memorandum 95-205, *Prolegomenon to Any Future Naval OOTW Doctrine, Volume 1: Discussion,* by Lester L. Gibson and CDR Paul Dunne II with Peter Swartz, March 1996.

Table 8. Operations Other Than War (OOTWs)[a]

- **Operations to assist, deter, and respond to foreign governments**
  - **Operations to assist foreign governments**
    - Foreign internal defense
      - Counter-insurgency operations
      - Anti-insurgency operations
      - Quelling civil disturbances
    - Naval exercises with foreign militaries
    - Military actions directed at civilians and civilian populations
  - **Operations to deter hostile governments**
    - Surveillance and patrols
      - Peacekeeping/maritime peacekeeping
    - Show of force
      - Freedom of navigation
      - Preventative deployment
  - **Operations to respond to hostile governments**
    - Peace enforcement/peace imposition
    - Strikes and raids
      - Combat search and rescue
    - Military restrictions on trade
      - Maritime interception operations
      - Quarantine
- **Operations to aid, protect, and control civilians and civilian populations**
  - **Operations to protect and aid victims of natural disasters**
    - Disaster/humanitarian relief
    - Permissive non-combatant evacuation
    - At-sea search and rescue
  - **Operations to protect and aid victims of crime and man-made disasters**
    - Humanitarian security operations
    - Non-permissive non-combatant operations
    - Protection of shipping
  - **Operations to aid and control displaced victims**
    - Alien migration interception operations
    - Refugee processing
    - Refugee control
  - **Operations to control international criminal behavior**
    - Counter-piracy operations
    - Counter-smuggling operations
      - Counter-drug operations
    - Terrorism control
      - Counter-terrorism
      - Anti-terrorism
        - Key asset defense

a. Source: CNA Research Memorandum 95-205.

operations, alien migration control, maritime search and rescue, and counter-drug operations—all missions that emphasize traditional Coast Guard strengths. Many of these missions could be important in time of war as well (see page 69).

In addition, the Coast Guard has unique and longstanding capabilities for polar operations. This was one of the reasons that President Roosevelt selected the Coast Guard to conduct preemptive operations in Greenland in the months before Pearl Harbor.

Assumptions about U.S. strategy

The role of the Coast Guard will be determined both by the evolution of the international security environment and by the response of the United States to the challenges posed. The responses will reflect taskings by the country's political leadership, the President and his advisors, and the Congress. The success of what the government chooses to do, however, will be determined by the views and political support of the American people.

We assume that U.S. national security strategy will evolve over time, depending on changes in the international environment, the attitudes of the American people, and the policies of future administrations. Regardless of such changes, we believe that the United States will continue to adhere to the following generalized set of interests and values in its foreign policy:[85]

- A peaceful, stable system of regional relations with no domination of any region by a power hostile towards the United States. We will prefer managed resolution of conflicts.
- Continued reliance on cooperative relations.
- Expansion of democratic government.
- Growth and development of the world's economy on free-market principles that ensure full U.S. access for trade and investment.

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85. Adapted from CNA Memorandum 95-172, *The Dynamics of Security in the Asia-Pacific Region*, by M. Lyall Breckon and Thomas J. Hirschfeld, January 1995, p. 41.

- Responsible practices in transnational areas of concern.
- Prevention of proliferation of weapons of mass destruction and means of delivery.
- Unimpeded access and transit for naval forces.

International security environment: alternative visions

There is considerable disagreement over the character of the international security environment. Consider the following five alternative worlds currently postulated by different experts in international affairs. We describe these visions not because they necessarily reflect any plausible alternative, but because they indicate how well-informed, intelligent observers can construct radically different visions of the future.

Clash of Civilizations. Samuel P. Huntington has argued that the beginning of the 21st century will be characterized by conflicts between groups defined by shared cultural identity, rather than by nation-states (as was the case until the early 20th century) or ideology (as was the case through much of the 20th century). In his view, the future will be characterized by conflicts between the West (which includes the United States and West Europe) and other civilizations, especially what he terms the Islamic and Confucian (China).[86]

The Coming Anarchy. Robert B. Kaplan argues that the defining characteristic of the future will be the collapse of the traditional nation-state.[87] Reflecting the views of the military historian Martin van Creveld, Kaplan argues that the world is becoming divided between the "haves" who live in a secure world of nation-states and many "have nots" who live in a Hobbesian world of conflict and terror. In this

86. Samuel P. Huntington, "The Clash of Civilizations?," *Foreign Affairs*, Summer 1993, pp. 22-49.

87. Robert D. Kaplan, "The Coming Anarchy," *The Atlantic Monthly*, February 1994, pp. 44-76. See also his *The Ends of the Earth: A Journey at the Dawn of the 21st Century* (New York: Random House, 1996).

world, Somalia and Bosnia are the norm, not the exception, and most conflict does not involve the traditional nation-state.[88]

Peer Competitor. Individuals associated with the Office of Net Assessment in the Office of the Secretary of Defense believe that "a peer competitor to the United States will eventually arise" sometime after the 2010 timeframe. From this perspective, the primary concern for the United States should be the inevitable emergence of a state with global capabilities capable of matching the power of the United States and its allies and friends. In addition, the United States will face lesser threats from so-called niche competitors, who will possess limited capabilities that enable them to pose regional challenges to the United States and its allies and friends.[89]

The End of History. Frank Fukyama, an analyst associated with the RAND Corporation, has postulated that the end of the Cold War represented a watershed in the international system. In Fukyama's view, the ideological struggles that had dominated the previous century came to an end with the triumph of liberal democratic capitalism. He explicitly does not predict the end of inter-state conflict or of conflict in general, and recognizes that the human emotions that enable violence remain even in the most pacific of societies.[90]

Although some aspects of some of these alternative visions are similar, they also reflect profoundly different views of humanity, of the transformation of the international system, and of the likely challenges that we will face in the opening years of the 21st century.

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88. Martin van Creveld. *The Transformation of War* (NY: Freedom Press, 1991).

89. For an assessment of these issues as viewed by an analyst associated with the Office of Net Assessment in the Office of the Secretary of Defense, see Jeffrey R. Barnett, *Future War: An Assessment of Aerospace Campaigns in 2010* (Maxwell Air Force Base, Alabama: Air University Press, January 1996).

90. Frank Fukyama, "The End of History?," *National Interest*, Summer 1989, pp. 3-18, and *The End of History and the Last Man* (New York: Free Press, 1992).

Significantly, every one of these visions leaves open the possibility for violence, and especially for low-level violence of the types often associated with OOTW. Even the most optimistic view represented here recognizes the possibilities for conflicts requiring military force. Equally significant, the greatest degree of agreement about the existence of threats concern those at the lower ends of the spectrum of conflict: all agree on the continuation of low-level violence, but not all agree on the likelihood or source of large-scale inter-state conflict.

As this short survey suggests, we cannot comfortably predict the structure of the international security environment in 25 years. We cannot predict whether there will be a peer competitor, or whether the international system will be characterized by cooperation and order or by division and anarchy, or whether the fault lines of the future will be based on ethnicity, ideology, or greed.

Nevertheless, we can make certain assertions with substantial confidence. Under almost any circumstances the United States will require the types of military capabilities required for OOTW missions. We cannot predict the extent of the requirement for OOTW capabilities. These will depend on the continuing evolution of national strategy and of developments in the international arena. We can comfortably predict, however, that there will be a continuing demand—probably a significant one—for OOTW capabilities.

Where the Coast Guard fits

The Coast Guard can provide assets capable of addressing several military missions. Some of these missions derive from the inherent capabilities of the Coast Guard's high- and medium-endurance cutters to supplement the Navy's surface combatant force. The Coast Guard also has other assets to contribute to defense missions, and Coast Guard personnel have other skills not necessarily tied to the cutters.

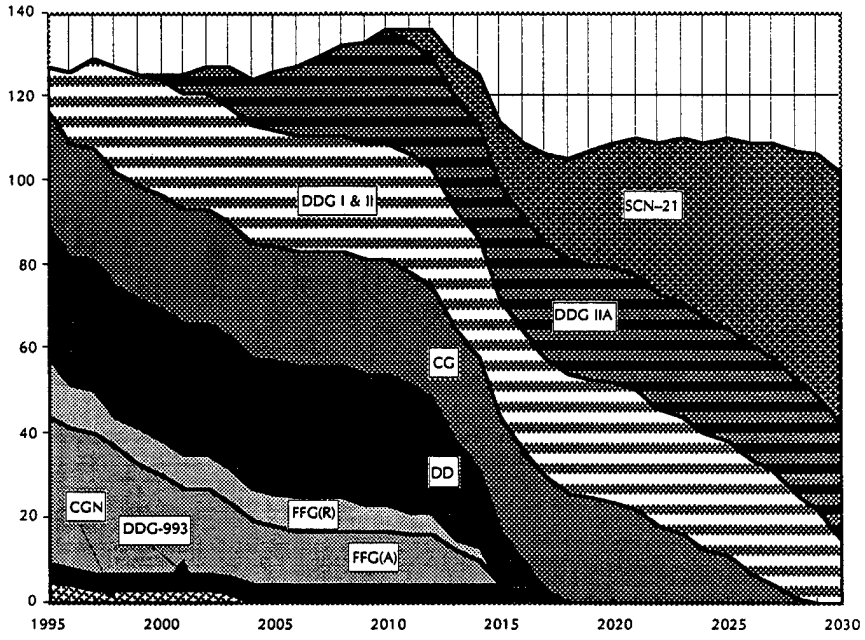
Supplementing Navy surface combatants

Given the long lead time for ship procurement, it is possible to predict with some accuracy the size of the U.S. Navy's surface combatant fleet far into the future. We also know what kinds of ships are likely to be in the inventory during that period. Beyond 2015, it becomes more difficult to predict the composition of the surface fleet, given

uncertainties about the number and types of ships that will be procured as a result of the Navy's SC–21 review of its surface combatant force[91]

Figure 1 shows the predicted trends.This graph assumes that the Navy surface combatant procurement budget permits acquisition of three additional SC–21 ships every year. Under these conditions, the U.S. Navy may have no more than about 110 surface combatants by the year 2020, compared with 127 in 1995 (including 14 FFG–7 frigates assigned to the reserve forces), albeit each more capable than many of the ships in the current surface combatant force. Although the size of the force might increase after that, it is just as likely to decline, depending on what resources are available for procurement.

Figure 1. U.S. Navy surface combatants



91. For purposes of analysis, we have accepted the SC–21 model as a typical direction for Navy force planning.

In the long run, the size and shape of the Navy will also depend on the state of the international security environment. The emergence of a peer competitor, for example, or concern that one might emerge, would probably lead to increases in ship procurement.

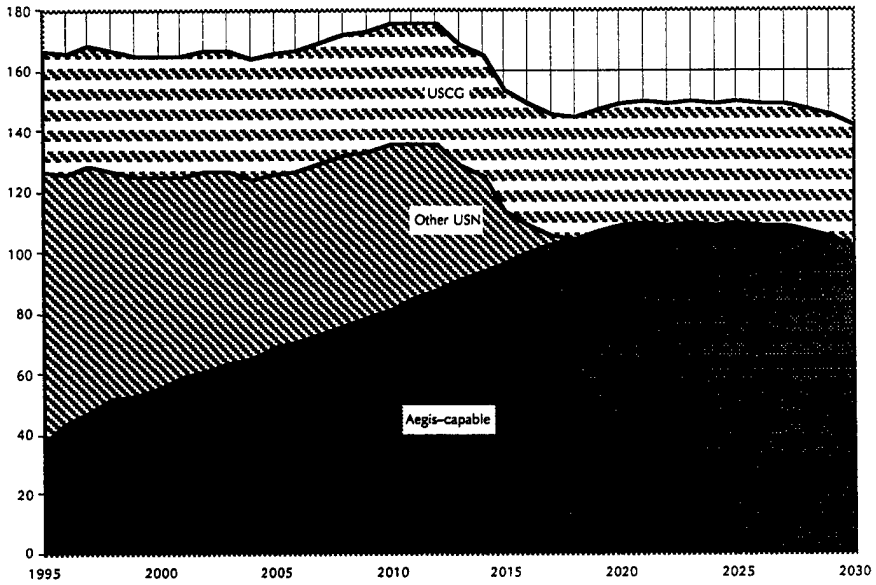
What appears more certain is that the Navy ship inventory will consist largely of increasingly capable ships and low-end ships may largely disappear from the force. As the FFG–7 frigates are removed from active service (by 2015), the Navy will be left with a surface force that consists largely (or completely) of high-capability Aegis-equipped ships. (See figure 2.) These ships will be larger and considerably more capable than the frigates. Hence, the result is a force that is more appropriate for operating against high-end threats than against those at the low end. Even should the Navy decide to procure some less expensive, less capable ships than those now contemplated, the least capable Navy ship is likely to be far more sophisticated and expensive than the Coast Guard cutters with the most capable war-fighting suites.

Although the highly capable ships that will compose the Navy's surface combatant force can conduct OOTW missions, their likely deep draft may limit their utility under many circumstances. For example, when undertaking maritime interception operations, the ships will not be able to operate in shallow waters that could be used by merchant ships seeking to transport goods in violation of a sanctions regime.

By comparison, the Coast Guard currently has a fleet of just over 40 high- and medium-endurance cutters.[92] This force currently amounts to just under one third of the U.S. Navy surface combatant force. A fleet of 40 cutters would consist of about 35 to 40 percent of the total U.S. Navy surface combatant forces in the post-2010 era. Equally important, the ships available to the Coast Guard are likely to be better suited to many of the OOTW challenges that are expected to remain.

92. We assume here that as the Coast Guard replaces its existing cutter fleet with more modern ships, no change is made in the overall size of the fleet.

Figure 2. Total U.S. surface combatants (USN/USCG)



Wartime roles and missions are as difficult to define as the nature of future wars. The higher proportion of USCG hulls to the declining number of Navy hulls suggests that the cutter fleet may be tasked with considerable backfill work. Coast Guard cutters also might be employed to conduct presence operations in areas distant from a conflict and could be tasked with missions in the theater of operations, such as maritime interception operations and merchant ship escort duties. This poses interesting problems for the Coast Guard's logistic infrastructure.

Other Coast Guard assets

Previous major conflicts suggest that there will be a need for Coast Guard boats, aircraft, and personnel for coastal and port security. Terrorist threats, especially those that may loom large in the popular imagination, might inspire demands for intense port security along the entire seaboard, as was the case during the Spanish American War.[93] The Coast Guard also would provide port security for forward-deployed forces. In addition, there may be a requirement to perform

some of the OOTW missions identified in table 8, many of which could be performed by Coast Guard assets.

As noted in table 9, many Coast Guard missions will not be performed by cutters. Rather, the Coast Guard will contribute small craft, port security units, law enforcement detachments, oil spill response teams, or specialized craft (such as icebreakers). In addition, Coast Guard personnel with specialized skills may be used to address particular issues of CinC concern.

In addition, it must be stressed that many of these tasks may not involve working directly for the Navy. In the wake of the Goldwater–Nichols defense reforms, the Department of Defense has placed increasing emphasis on jointness and the position of the Unified Commanders in Chief has been enhanced. The Navy itself is becoming part of an increasingly joint armed force, organized operationally under unified regional commands.

It is possible that regional CinCs could develop quick-response or long-term requirements for Coast Guard assets. Cutters clearly support naval component commanders' requirements, but other Coast Guard assets, small boats, helicopters, surveillance aircraft, or personnel could also support other service components in special operations, boarding, meteorology, or other staff work. It might therefore be worth exploring whether the Coast Guard's defense relationships could be expanded beyond the Navy, such as with Special Operations Command, to ensure the full use of Coast Guard assets.

93. Rumors of Spanish invasion sparked popular fears of threats to the coastal areas. See G.J.A. O'Toole, *The Spanish American War* (New York: W.W. Norton, 1984), pp. 194–195.

Table 9. Coast Guard defense missions[a]

Mission	Description	Coast Guard assets
Maritime interception operations	Enforcing maritime portion of sanctions against another country	Cutters, law enforcement detachments
Coastal/port security	Protecting US coasts and ports and security of ports needed by US forward deployed forces; can include offshore asset protection, counter–terrorism, salvage, and aids to navigation	Maritime defense zones, port security units, law enforcement detachments, cutters, and small craft
Environmental defense	Responding within context of military operation	Oil spill response teams, cutters, aircraft, and small craft
Noncombatant evacuation	Evacuating U.S. civilians from a foreign country resulting from threats to their safety	Cutters, small craft, and aircraft
Ship escort	Protecting combatants, logistics, or commercial ships from air, sea, or undersea threats	Cutters
Sea lines of communication patrol	Maintaining maritime superiority in significant strait or sea lane	Cutters
Support for special forces	Supporting embarked special teams and inserting/extracting special forces	Cutters and small craft
Search and rescue	Performing search and rescue in low-threat environments for merchant ships or refugee vessels	Cutters and small craft, and aircraft
Ice breaking	Providing ice breaking support to U.S. military, both domestically and elsewhere	Icebreaking vessels, aircraft
Presence operations	Operating as another forward presence tool for unified CinCs	Cutters, training teams and other detachments
Aid to navigation	Supporting maritime navigation requirements of DoD	Cutters, small craft, tenders
Intelligence-surveillance-reconnaissance	Monitoring environmental conditions, aircraft or ship movements, intelligence collection	Cutters, small craft, and aircraft

a. Adapted from CNA Research Memorandum 96–90, *Future Coast Guard Cutter Study: National Defense Requirements*, August 1996, by Richard D. Kohout with CAPT Patrick H. Roth, USN (Ret.).

Bottom line

Several conclusions emerge from this survey of defense-related trends in the national defense arena. First, irrespective of the character of the overall international security environment, OOTW missions will remain. Thus, whoever is leading the country in 25 years is likely to

want forces capable of performing such missions. The interest of the regional Commanders in Chief in OOTW missions appears to be growing, despite the ascribed warfighting roles of the CinCs, which some analysts suggest imply a return to patterns of behavior from before the Cold War. Second, the ability of the U.S. Navy to undertake such missions is likely to diminish, given the decline in the size of the surface combatant force, its increasing sophistication, and the likely disappearance of shallower-draft ships. Moreover, the U.S. Navy's surface combatants may be less well suited to performing OOTW missions, because they are too large or too highly focused on high-end missions.

What we cannot define, however, is the requirement for platforms suited for OOTW missions. This depends on the evolution of the international system and of the resulting adjustments in U.S. policy and strategy. These factors are unknown, and ultimately unknowable. This analysis also does not indicate where the Coast Guard should put its national defense resources. Alternatively, it could provide small craft and specialized forces needed for the harbor defense and littoral warfare missions, or it could emphasize high- and medium-endurance cutters for other missions.

Economic trends

Coast Guard-relevant economic trends include the following:

- Fisheries law enforcement remains important.
- Off-shore resource exploitation continues.
- Ocean thermal energy conversion is unlikely.
- Vessels grow in numbers, size, and speed (in commerce with the U.S.).
- Size of U.S. merchant fleet declines.
- Number of HAZMAT carriers grows (in commerce with the U.S.).
- Number of barges and tugs grows.
- Number of passenger vessels grows somewhat.
- Gambling/gaming vessel numbers remains stable.
- Containerized cargo is consolidated in fewer, deeper draft ports.
- Traffic is congested in certain ports.
- No new deepwater ports are added; ships continue to rely on lightering.
- Long-term intermodal growth occurs.
- Oil traffic grows in short term growth, declines in long term.

Fisheries law enforcement remains important

Trends in world fisheries

In 1993, the most recent year for which data are available, world commercial fishery landings were 101.4 million metric tons (mmt), an increase of 2.6 metric tons (3 percent) over 1992. [94] FAO statistics indicate that the grand total of world commercial catch of fish, crustaceans, and mollusks has risen over the past five years, from 100.115 million metric tons in 1989 to 101.418 million metric tons in 1993. An

94. The leading fishing nation was China, accounting for 17.3 percent of the total catch; Peru ranked second, with 8.3 percent; Japan third, with 8.0 percent; Chile fourth with 6.0 percent; the United States fifth, with 5.9 percent; and Russia sixth, with 4.4 percent. Fisheries of the United States, 1994: iv.

important point, however, is that the world catch in marine areas has fallen over the same period.[95] The difference has been made up by increasing commercial catches in inland waters, especially in Asia. In 1989, inland water catches amounted to 13.925 mmt (of which 9.658 mmt were in Asia); in 1993, that total had risen to 17.169 mmt (of which 13.301 were in Asia).

Commercial landings (both edible and industrial) by U.S. fishermen in 1994 registered 4.745 million metric tons, valued at a record $3.846 billion. Although this represented an increase in value of $375 million over 1993, the level of catch actually decreased from 1993, when the total U.S. catch was reported as 4.747 mmt.[96]

The U.S commercial fish catch from 1958 to 1993 increased, although rates differ depending upon which data base is used. Statistics published by the United States clearly indicate that the U.S. commercial catch has risen in a near-progressive pattern since 1970, from 2.2 mmt to 2.9 mmt in 1980, to 4.3 mmt in 1990, to 4.7 mmt in 1993. Statistics complied by the UN Food and Agriculture Organization, however, suggests a more erratic pattern, from 2.8 mmt in 1979, to 3.6 mmt in 1980, to 5.9 mmt in 1990, to 5.9 mmt in 1993. The general trend remains the same, however: The U.S. commercial catch continues to increase, albeit with notable dips (e.g., 5.5 mmt caught in 1991, 5.6 mmt caught in 1992). Significantly, the pattern of U.S. commercial catch runs consistently with the pattern indicated for the world commercial fish catch during the same period.[97]

Statistics of U.S. imports of fishery products since 1985 suggest important trends as well. In 1985, the United States imported 2.75 billion pounds of edible and nonedible fishery products, valued at $6.687 billion. In 1989, a record 3.243 billion pounds were imported, at a value

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95. For the Atlantic, Pacific and Indian Oceans, the total catch reported in 1989 was 86.19 million metric tons. Since then, data suggests a labored, unsuccessful effort to maintain that level. In 1990, the ocean catch was 82.690 mmt; in 1991, 82.46 mmt; in 1992, 83.075 mmt; and in 1993, total catch increased, but only to 84.249 mmt. Ibid.

96. National Marine Fisheries Service, *Fisheries of the United States*, 1994: 2.

97. *Fisheries of the United States*, 1994: 27.

of $9.604 billion. After falling to 2.884 billion pounds in 1990, by 1994 the level of imports had climbed back to 3.034 billion pounds, having a record value of $11.986 billion.

These statistics suggest that the trend for the United States will be to import increasingly more fishery products in the future, at increasingly higher costs. This increasing dependency on imports can be explained by greater demand in the United States for fish and nonedible fishery products, a declining domestic fishing industry that is unable to catch sufficiently greater amounts of fish, the decreasing availability of domestic fishery stocks, and the inability of inland fisheries or aquaculture to compensate for the difference between available supply and increasing domestic demand.

Developments affecting straddling stocks

The most problematic Law of the Sea issue affecting international relations since the 1982 LOS Convention was negotiated has been that of straddling stocks. Several episodes have tested the feasibility of enforcing international fisheries regulations under the Convention. The diplomatic upshot of these trials, however, is the creation of new, more viable laws that should remain in place over the next two decades.

International law affecting straddling stocks

About 90 percent of living marine resources are harvested within 200 n.mi. of the coast. By authorizing the establishment of exclusive economic zones 200 n.mi. from shore, the 1982 LOS Convention allocates to coastal states the sovereign rights and management authority over living resources, including fisheries, within their EEZs. Some fish species, however, "straddle" the region between some coastal states' EEZs and the high-seas areas beyond and adjacent to those EEZs. These fish stocks move in and out of the jurisdictional areas of coastal states. There are also other highly migratory fish stocks, which are essentially high-seas stocks, although they may in the course of migration move through the EEZs of coastal states. Although the 1982 LOS Convention gives to coastal states exclusive powers to control fisheries within their EEZs, it does little to regulate those fishery resources that are not found within, or which temporarily pass through, those juris-

dictional zones. The applicable provision for high-seas stocks, Article 87 of the LOS Convention, provides that "The high seas are open to all states, whether coastal or land-locked. Freedom of the high seas is exercised under the conditions laid down by the Convention and other rules of international law." For joint or shared stocks—including transboundary or straddling stocks—the obligation of relevant coastal states and states whose vessels fish these same species on the high seas is to "seek to agree" on measures necessary for conservation.[98]

The reduction of high-seas areas by the worldwide enclosure of 200-n.mi. zones, the resultant search for new fishing grounds and potential target species by distant-water fishing fleets, and the continued rise in fishing capability throughout world by more vessels equipped with more sophisticated harvesting technology brought the tension between coastal states and fishing nations to a crisis level during the 1990s. Over the past five years, a fundamental conflict of interests arose between distant-water fishing nations with improved high-seas fishing capabilities in search of new fishing grounds and coastal states concerned about the need to conserve fishery stocks within their EEZs.

Advancements in technology have enabled fishermen both to find and to harvest more fish. Spotting aircraft, echo sounding devices, and even satellite information now help locate fish. In addition, advances in scientific research have contributed substantial knowledge about fish behavior and migration habits that have greatly aided fishermen. Enhancements in fishing vessel design have contributed. Larger, more powerful vessels can range over longer distances and operate in more difficult conditions in areas where fish concentrations are more abundant. The introduction of fish-processing equipment on board large-stern trawlers reduced the need for port facilities to off-load catches. These factory trawlers transfer processed catch to transport vessels and refuel at sea to continue their constant operations. Improvements in fishing gear have also kept pace. The most notable advance has been the development of mid-water trawl

98. 1982 LOS Convention, Article 63.

technology, which makes possible more effective exploitation of high-seas living resources. These advances fostered creation of distant-water fishing fleets by Japan, the former Soviet Union, the United States, and more recently, South Korea and Taiwan, among others.

The consequences of these developments are apparent: the total annual harvest from the sea has increased from a 1957 level of 31 million metric tons to 100 million metric tons in 1994. According to the most recent catch data available, world fishery catches have reached the 100-mmt limit suggested by the UN Food and Agricultural Organization (FAO) as the maximum global yield producible on a sustainable basis.

The Bering Sea "donut hole" pollack fishery

The Bering Sea region in the North Pacific Sea became a source of international tensions between the Bering Sea coastal states (i.e., Russia and the United States) and distant-water fishing states (viz., Japan, South Korea, Poland, and China) over migratory stocks of Alaskan pollack. The 1977 extension of 200-n.mi. fishing zones seaward from the United States and former Soviet Union produced a configuration such that overlapping EEZs left high-seas enclaves in the center of the Bering Sea, in the shape of donut holes. The legal dilemma concerning fisheries' jurisdiction over straddling stocks was thus joined, as Russia and the United States maintained fishing/conservation zones around areas in the Bering Sea that were open to high-sea freedoms to fish. When pollack stocks were found within those EEZs, they were protected from being fished by distant-water fishing nations. However, when those stocks moved into the high-seas enclaves—the donut holes—they became susceptible to lawful harvest by foreign fishing fleets, raising serious concerns about overexploitation. In 1989, Russian and U.S. fishermen reportedly harvested nearly 1,450,000 tons of pollack stocks in the donut hole. In 1990, only 917,000 tons were taken, and in 1991, the reported catch dropped to 293,000. Apparently, significant amount of pollack were being taken by foreign fishing fleets and Alaskan pollack stocks in the Bering Sea were being depleted at an alarming rate, presumably as they were additionally being fished intensely by Japan, South Korea, China, and Poland.

An important step toward resolving this confrontational situation came in 1994 through negotiation of the Convention on the Conservation and Management of Pollack Resources in the Central Bering Sea. (It was signed in Washington, DC, on 16 June 1994 by China, South Korea, Russia, and the United States; Japan on 4 August and Poland on 24 August 1995). This Convention provides that signatory states will meet annually to decide harvest levels and to establish catch quotas. It also adopts a precautionary approach to fishery conservation in that no fishing is permitted unless the Aleutian Basin pollack biomass is determined to exceed 1.67 million metric tons, to be determined by parties jointly, or failing this, by the United States and Russia, or failing that, by the United States unilaterally.

The "peanut hole" in the Sea of Okhotsk

The Sea of Okhotsk is virtually surrounded by the territory of the Russian Federation which, when EEZs were extended seaward by Russia, created a high-seas enclave in the shape of a peanut. Hence the name "peanut hole." Although its fishermen had traditionally fished in that region, the Japanese government moved to respect a ban on fishing imposed by the Russians in the late 1980s.

In 1991, presumably as the consequence of reduced fishing in the Bering Sea, vessels from China, South Korea, Poland, and Panama moved into the enclave. The Russians complained in 1992 that this intensified multinational fishing effort in the peanut hole was destroying the conservation and management system for the pollack fishery as spawning stocks were being decimated, and producing adverse effects on other commercial stocks, in particular herring, halibut, and salmon. The situation became internationally tense in 1992–93.

This confrontation resulted in international negotiation. A first Conference on the Living Resources of the Sea of Okhotsk was convened 31 May–1 June 1993, with Russia, Poland, South Korea, and China represented. Although agreement on catch levels was not reached at that time, subsequent measures prompted China and South Korea to agree in late 1994 to refrain from fishing in the enclave. Presumably, the international law emerging for the regulation of high-sea enclaves in semi-enclosed seas (namely, Articles 61, 62, 63, and 123 of the 1982

LOS Convention), coupled with the legal principles emerging from the 1995 Straddling Stocks Agreement (see below), should clarify the rights and duties for the applicable regime for straddling stocks in areas such as the "peanut hole."

Western Pacific tuna fishery

A serious dispute arose during the 1980s between the United States and Pacific Island governments over attempts by the South Pacific Forum Fisheries Agency to impose fishery controls over U.S. vessels fishing for pelagic tuna in high seas and EEZ areas. The official U.S. position was that tuna was a migratory species, beyond the limit of coastal state control, except in accord with agreements reached under Article 64 of the 1982 LOS Convention. In 1987, following a series of international incidents, the United States agreed to a treaty with 16 states of the South Pacific Forum that accepts the right of that group to regulate tuna fishing on a regional basis.[99] This agreement carries considerable significance in that it regulates access by U.S. fishing vessels to the entire tuna fishery on a regional basis. The treaty not only encompasses EEZs of the FFA states, but also the adjacent high-seas areas. In return for tuna fishing licenses, the U.S. Government agreed annual access fees for a five-year period of $18 million.

Japan, South Korea, and Taiwan have not accepted this approach, preferring instead to enter into a series of bilateral EEZ access agreements with particular island states and to fish in adjacent high-seas areas and enclaves. Two additional international agreements, however, have enhanced capabilities for regional surveillance and enforcement. In May 1993 the Niue Treaty on Cooperation in Fisheries Surveillance and Law Enforcement in the South Pacific Region came into force. This innovatory agreement provides a framework for concluding bilateral agreements aimed at surveillance of foreign fishing fleets in 200-n.mi. EEZs of member states. In addition, an agreed minute on Surveillance and Enforcement Cooperation was negoti-

99. Multilateral Treaty on Fisheries: Treaty on Fisheries between the Governments of Certain Pacific Islands and the Government of the United States of America, Forum Fisheries Agency, 1994.

ated and signed between the United States and the FFA states in March 1993 as a supplement to their existing Treaty on Fisheries.

The Chilean *Mar Presencial*

During the 1980s, distant-water fishing fleets from Russia, Bulgaria, Poland, and Cuba undertook intensive exploitation of Chilean jack mackerel in high seas beyond the 200-n.mi. limit claimed by Chile. The swimming range of these mackerel extends as far as 2,000 n.mi., and they spawn anywhere from 100 to 250 n.mi. offshore. Large-scale exploitation of the Southeast Pacific fishery began in 1977 as fleets from the Soviet Union, Bulgaria, Poland, and Cuba were displaced from areas that recently had been subsumed under national jurisdiction.

In response to these developments, in 1991 Chile enacted a Fisheries Act designating a special zone extending over nearly 20 million square kilometers of ocean space, running from Easter Island to the Antarctic. This zone was designated the *mar presencial,* literally "the sea in which we are present."

Chile's *mar presencial* concept represents a national attempt to protect coastal fisheries of the EEZ by creating an expansive buffer zone area in adjacent areas of the high seas. Although national conservation and management of straddling stocks may be admirable, resort to unilateral measures that contravene generally accepted norms of international fisheries law may be conflictual. At present, the *mar presencial* exceeds the realm of contemporary international law, as it would reserve more than 7,709,000 square miles of ocean space for Chile's special oversight—ocean space that has traditionally been universally acknowledged as high-seas area.

The critical implication of Chile's presential sea proclamation was the prospect that "creeping" jurisdiction could immediately become "leaping" jurisdiction. That is, that a coastal state could exercise a unilateral right to claim and enforce some form of hitherto unknown jurisdiction over vast stretches of ocean space in internationally recognized high-seas regions.

The legal nature of Chile's *mar presencial* zone remains vague and undefined, not only in terms of Chile's fishing policy, but also in terms of Chile's sovereign rights and obligations within that zone. This zone is not claimed territory; it is not a designated national fishing zone, approved and defined under international law; nor is it a form of expansive EEZ. The *mar presencial* is sui generis, without precedent or sanction in international law.

Significantly, no government has formally recognized the lawfulness of such a unilateral assertion. More important, successful negotiation of the Agreement on Straddling Stocks in 1995 has provided a legal mechanism for dealing with the situation of foreign distant water fleets fishing beyond Chile's offshore 200-n.mi. zone.

In March 1996, Chilean Navy Commander Jorge Martinez Busch (who originated the *mar presencial* concept) suggested the notion that coastal states should retain special "subsistence sovereignty rights" in a "contiguous sea" region adjacent to and beyond the exclusive economic zone. Nevertheless, such an assertion does not represent Chile's officially declared policy toward the current law of the sea.

So long as the *mar presencial* remains a geostrategic concept in theory, rather than an avowed legal principle in practice, it will be provocative but not confrontational.

The Canadian-European Union Turbot War

On 9 March 1995, Canadian Coast Guard patrol boats seized a Spanish-registered vessel, *Estai*, on the high seas beyond Canada's jurisdictional waters off Newfoundland. This action was taken on grounds that the trawler had violated Canada's fishing laws applicable to that area. The incident, touching off a six-weeks-long diplomatic dispute unprecedented in scope and dimension between Canada and the European Community (EC), produced such salient legal, economic, social, and political ramifications that the entire episode became known as the "Turbot War." It also tested the diplomatic utility and wherewithal of the North Atlantic Fisheries Organization (NAFO), under which regional fisheries policy for Canada, Spain, and the European Union in the North Atlantic was managed.

The 1995 Turbot War produced important ramifications for international ocean law. Its impact can be seen in the issues affecting both regional and international management of fishery stocks, as well as in the concomitant compatibility of conservation measures.

The United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks in August 1995 adopted through consensus the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. In adopting this agreement, the conference overcame the political fallout from the recent Canada-EC bilateral conflict and created useful rules with worldwide application. Perhaps not surprisingly, adoption of the UN Straddling Stocks Agreement and the Canadian-European Community fisheries dispute were deeply interrelated.

Canada's main concern was to secure a regulatory system that guaranteed compatibility of conservation measures within and beyond national EEZs. Because straddling stocks inhabit areas that overlap coastal states' jurisdictions as well as portions of the high seas, they are especially vulnerable to conflicting regulations. No matter how strict the conservation measures imposed by a coastal state within its jurisdictional zones, if the management regime on the adjacent high seas is not as strict, or is not fully enforceable, then the overall effectiveness of the coastal state's measures—and overall species conservation—will be compromised. Canada intended to impose such compatibility by pursuing a de facto police role on the high seas for coastal states bordering the Northwest Atlantic.

The agreement reached in May 1995 to settle the dispute between Canada and the European Community bolsters the role of regional fishery organizations in marine conservation and ocean management.

The NAFO regime is strengthened in terms of enforcement and monitoring of regional fisheries activities. In considerable part, the Canadian-EC conflict stemmed from weaknesses and ambiguities in the existing Law of the Sea under the 1982 Convention. New provisions contained in Annex I of the Protocol appear regulatively sound and

more capable of fulfilling—and therefore significantly improving—those shortcomings in the legal regime that had precipitated conflict in the first place. In general, the final agreement "increases the range of permissible non-flag-state monitoring and enforcement actions," a fact that undoubtedly will permit more able and consistent regulation of fisheries within the NAFO region.

Emerging law

The FAO compliance agreement

In 1994, the Food and Agriculture Organization completed negotiations on and opened for signature its Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas. This instrument establishes minimum requirements to be applied by flag states for the registration and authorization of fishing vessels intended for fishing on the high seas. Its main objective is to prevent vessels from undermining the effectiveness of conservation and management measures by reflagging. With respect to nonparties, the Agreement determines that parties to the instrument shall cooperate, consistent with international law, to prevent vessels of nonparties from engaging in activities that would undermine the effectiveness of international conservation and management measures.

The straddling stocks agreement

The Straddling Stocks Agreement addresses concerns of jurisdiction and management without departing from the general framework of the Law of the Sea. General provisions in the agreement express, *inter alia*, determination of the parties "to ensure the long-term conservation and sustainable use of straddling stocks....through effective implementation of the relevant provisions of the Convention [on the Law of the Sea]" (Article 2). Although applicable only beyond areas of national jurisdiction (Article 3 (1)), coastal states are nevertheless required to observe a number of general principles of law. Among those are the duty to cooperate (Article 5), to ensure the long-term sustainability of straddling stocks (Article 5(a)), to apply the precautionary approach (Article 6), to ensure compatibility of conservation

and management measures (Article 7), and to adopt measures based on the best scientific advice available (Article 5 (b)).

The UN Straddling Stocks Agreement calls upon coastal and flag states to develop provisional arrangements and to inform each other reciprocally about their respective national regulations and legislation (Article 7 (6), (7), and (8)). It also provides that, should no agreement be achieved on compatibility of conservation and management measures, "any of the States concerned" may bring the issue to binding and compulsory dispute settlement, using procedures set out in Part VIII of the Agreement.

A truly significant contribution of the UN Straddling Stocks Agreement is that it confirms the importance of regional and subregional organizations for international fisheries management, strengthens their jurisdictional purview (Article 13) and stipulates that "States shall give effect to their duty to cooperate by becoming members of such organization or participants in such arrangement, or by agreeing to apply the conservation and management measures established by such organizations or arrangement" (Article 8(3)).[100] Further, "Only those States which are members of such an organization or participants in such an arrangement, or which agree to apply the conservation and management measures established by such organization or arrangement, shall have access to the fisheries resources to which those measures apply." (Article 8(4)).

In sum, the 1995 UN Agreement bolsters and extends the roles of regional and subregional organizations for resolving conservation and management issues regarding straddling fish stocks. The 1982 LOS Convention serves well as a framework agreement. Application and enforcement of that general international law, however, presum-

100. From the point of view of possible future opportunities for international cooperation in high seas law enforcement, the most important feature is the authorization of nations party to certain regional fisheries agreements to board and inspect on the high seas any ship from nations also party to the same agreement. If the boarded vessel is found to have committed a serious violation, it can be escorted to the nearest appropriate port for further inspection.

ably can be carried out more effectively by regional fishery organizations, as they are able to enforce regulations more strictly over localized fishing areas.

U.S. national law

The Magnuson Fishery Conservation and Management Act of 1982 (Public Law 94-265 as amended), provides for the conservation and management of all fishery resources within the U.S. exclusive economic zone. It also provides for fishery management authority over the continental shelf resources and anadromous species beyond the EEZ (except when they are found in another state's territorial sea of fishery conservation zone).

Title II of the Magnuson Act governs foreign fishing in the EEZ. In 1991 foreign fishing vessels were prohibited from conducting any harvesting or processing operations in the U.S. EEZ, thereby allowing the U.S. fishing industry to take advantage of underused species without competition from foreign fishing efforts.

Since 1991 there has been no total allowable level of foreign fishing activities permitted within the U.S. EEZ. Regulations under the National Marine Fisheries Service (NMFS) provide for foreign fishing permits and fee schedules, should future situations arise that might allow foreign fishing of an underused fishery within the jurisdiction of U.S. EEZ.

Under the Magnuson Act, eight Regional Fishery Management Councils are charged with preparing Fishery Management Plans (FMPs) for those fisheries requiring management within their areas of authority. These management councils have jurisdiction over the following regions: New England, Mid-Atlantic, South Atlantic, Gulf of Mexico, Caribbean, Pacific, North Pacific, and Western Pacific. Following development by the Councils, FMPs are submitted to the Secretary of Commerce for approval and implementation. The National Marine Fisheries Service and the Coast Guard are responsible for enforcing the law and these regulations.

Preliminary Fishery Management Plans (PMPs), which cover only foreign fishing efforts, are prepared by the Secretary for each fishery for

which a foreign state requests a permit. In 1995 at least five PMPs were in effect, covering the following species: foreign trawl fisheries of the Northwest Atlantic; hake fisheries of the northwestern Atlantic; Bering sea herring; Bering sea snails; and Atlantic swordfish and bluefish tuna. In 1995, at least 34 fishery management plans were in place, each applicable to an individual species found within waters under U.S jurisdiction. Included among those species are the American lobster, Atlantic bluefish, Atlantic mackerel, Atlantic salmon, swordfish, gulf and south Atlantic corals, Gulf of Mexico shrimp and stone crab, northern anchovy, Gulf of Alaska groundfish, high-seas salmon, Bering Sea and Aleutian Islands groundfish, and western Pacific pelagics.

Aquaculture and krill potential

Aquaculture

Aquaculture has continued to expand progressively since the 1980s as one of the fastest-growing food production activities in the world. In 1994, the total production of finfish, shellfish, and aquatic plants was valued at nearly $40 billion, with a record weight of 25.5 million tons. Freshwater culture accounted for 63 percent or 11.74 million tons of aquaculture production of finfish and shellfish, with 29 percent or 5.30 million tons from maricultural activities. The remaining 8 percent was from brackish-water activities (1.51 million tons).[101] Between 1992 and 1994, the global contribution of cultured finfish and shellfish to total fishery production increased from 14.3 to 17 percent.

Global aquaculture continues to be dominated by freshwater finfish production. In 1994 finfish production accounted for 51.2% of global production by weight, and 54 percent by value. Aquatic plants, mostly used for human consumption, accounted for 27 and 15 percent of production by weight and value, respectively.

The relative importance and contribution of these activities to national fishery production in quantity varies markedly between

101. FAO, www.fao.org/waicent/fishery.htm.

countries. In 1994 aquaculture production of finfish from China, India, and France contributed 51.2, 35.5, and 33.3 percent, respectively, to their total national fishery production. In contrast, in Japan, Norway, and the United States such aquacultural activities contributed only 10.6, 8.6, and 6.8 percent, respectively.[102]

In the United States, aquaculture production increased production from a total of 139.9 million metric tons (valued at $260 million) in 1983, to 226.9 million metric tons (valued at $520 million) in 1988 to 324.6 million metric tons (valued at $809.9 million) in 1993. (Fisheries of the United States 1994: 10). Consistently over that decade, the finfish species most important for U.S. cultivation has been catfish (62.3 mt, valued at $83 million, in 1983; 133.8 mt, valued at $225.5 million in 1988; 224.8 mt, valued at $352.9 million in 1993. As for shellfish, the species most commercially valued is the crawfish. Unlike finfish, though, crawfish harvests fluctuated considerably over the decade, from 31.5 mt (valued at $32.6 million) in 1983 to a high of 32.2 mt (valued at $34 million in 1990), dipping down to 25.7 mt (valued at $28.5 million) in 1993.

Global aquaculture production will continue to grow at impressive annual rates over the next two decades, and aquaculture will increasingly account for greater percentages of national finfish and shellfish production in selected states. Over the next two decades, China will continue to rank as the major aquaculture producer, which is not surprising given the tremendous food demands imposed by its population (1.2 billion and still growing). India and France should also maintain their preeminence in the aquaculture market.

Aquaculture is becoming more attractive in the United States, but expansion will remain slow and production will not accelerate much faster than the pattern set over the past decade. Although the national fishing industry is experiencing economic problems due to higher costs, declining stocks and increased high-seas competition from foreign distant-water fishing fleets, gaps in U.S. demand for fish are likely to be filled by increased imports of fish products from Canada, Thailand, Taiwan, Iceland, Ecuador, and China. For the foresee-

102. FAO, www.fao.org/waicent/fishery.htm.

able future, U.S. aquacultural production will continue to account for only 5 to 7 percent of national production of fin and shellfish, with the main species harvested being catfish.

Krill

The foundation prey species for the Antarctic marine ecosystem is the krill, a tiny shrimp-like crustacean that swarms in vast shoals of the Southern Ocean. The distribution of krill is circumpolar, but discontinuous, with major concentrations in the eddies and gyres of the East Wind Drift and especially in the Weddell Gyre, just north of the Antarctic Peninsula. Other areas with cyclonic surface currents, attracting large swarms of krill, include the Ross Sea; Amundsen Sea; Bellingshausen Sea; around South Georgia Island, in the Scotia Sea just north of the Orkney Islands; around the South Shetland Islands; and westward of the South Sandwich Islands. It is in those areas that rich patches of phytoplankton production are concentrated and krill populations tend to swarm. Of note, krill are absent north of the Antarctic Convergence.

Some 85 species of krill have been identified; the most common are the Euphausia superba, E. crystallorophias, Thysasnoessa macrura, and E. vallentini. The most numerous of these is E. superba, which reaches a length of 2 to 4 centimeters (0.8 to 1.6 inches). Estimates of the krill stock vary widely, from 500 million to 5 billion metric tons. The range in estimated total krill biomass in the Southern Ocean appears more reasonable—between 500 to 750 million metric tons.

As an organism, krill is rich in protein content: about 50 percent by dry weight, about the same amount as beefsteak or lobster. This protein-rich creature, which swarms in huge concentrations in the Southern Ocean, can be easily harvested; nets are cast over the side and tons of krill are hauled up each hour. In the 1970s and early 1980s, such a realization prompted speculation that exploitation of krill stocks could offer a tremendous food source for feeding the world's hungry, and hence might be of huge commercial value to entrepreneurial fishermen. Even so, few countries are engaged in krill fishing. The Soviet Union, Japan, and Poland were early leaders in krill fishing, and in more recent years, some fishing efforts have been conducted by Germany, Chile, and South Korea.

The krill-based ecosystem is one of the most efficient in the animal kingdom, and it remains key to appreciating the rather large secondary and tertiary bioproduction in the Southern Ocean. Large krill swarms in the Antarctic marine ecosystem attract large populations of whales to the area, as well as various fish stocks, seal populations, and sea bird breeding colonies. In this regard, the large biomass stored in krill swarms makes it attractive to consider for exploitation. Yet, historical experience in the Antarctic clearly indicates that living resources there—seals, whales, or fish—cannot sustain intense, prolonged exploitation after depletion of virgin stocks. The problem is made even greater by the structure of the Antarctic ecosystem and the complex interrelationship among seals, sea fowl, penguins, fish, and whales as they all compete for their primary food supply, krill. Given potential grave ecosystemic impacts, considerably more scientific study must be undertaken before krill stocks can be safely harvested in substantial quantities in the Southern Ocean.

Conservation measures adopted by the Commission of the 1980 Convention on the Conservation of Antarctic Marine Living Resources have set a precautionary limit of 1 million tons of krill that can be harvested in any one year throughout the Southern Ocean. This and other fishery conservation measures adopted by CCAMLR are to be monitored and checked by international inspections of fishing vessels, with enforcement and/or punitive measures administered by the flag state of that fishing vessel.

The potential for large-scale krill harvesting over the next two decades, either by the world community in general or the United States in particular is slight. The economic liabilities associated with harvesting krill will strongly offset whatever advantages might be perceived from the enterprise, thus removing the commercial incentive to catch krill in the Southern Ocean.

The great distance of the Antarctic from the major fishing nations and the lack of support services will remain problematic for krill fishermen. A number of serious impediments will continue to dissuade

massive krill fishing in the Southern Ocean, among them the following:

- Krill are caught by mid-water trawling, a technique quite different from conventional bottom trawling and requiring sophisticated technology. Powerful vessels are needed because of the drag of small meshed nets, and trawlers must be equipped with large processing decks to deal with the krill biomass.
- Krill spoil rapidly, after only a few hours on deck, even in very low temperatures. When intended for human consumption, krill must be processed within four hours, as opposed to 12 hours if krill meal is used for animal feed.
- Krill are very difficult to preserve; deterioration continues even if frozen rapidly and kept at temperatures -20 degrees C. Krill also has a very high fluoride content, 7 to 24 times higher than that permitted by the U.S. Food and Drug Administration. Commercially viable solutions for these processing difficulties will not be widely available by 2020.

The U.S. fishing industry has never shown an interest in harvesting krill; nor will it by 2020. The Soviet Union and Japan have demonstrated the greatest interest in krill fishing, but that has varied considerably over the past decade according to political and economic circumstances in both countries. In 1995, the krill catch increased to 118,000 metric tons, up from 88,800 mt in 1993/94 and 83,800 mt in 1992/93, although neither Russia nor Chile fished for krill this past season. The increase is explained by the increased catch by Ukraine in 1994/95 to 51,300 mt, up from 8,700 mt the previous year. Significantly, these totals are considerably lower that the record total catch in the 1990/91 season of 400,000 mt. Krill harvests are not likely to exceed that 400,000 mt over the next two decades. In any event, the United States fishing industry will not play a significant role in that fishery.

Trends in fisheries management

Globally, fisheries stocks will continue to decline while demand for them will continue to increase. Ultimately, the future of fisheries tech-

nology lies in aquaculture and fish ranching, thus rendering national fisheries activities concentrated mainly in the EEZ. As fisheries stocks in the high seas are depleted, fishing industries will continue to suffer higher rates of unemployment and economic dislocation, eventually forcing workers to abandon the industry. Aquaculture will contribute increasingly higher percentages of total worldwide fish production. Even so, the resort to aquaculture will occur only slowly worldwide. Although international development and acceptance of aquaculture will surely grow, that growth will be gradual and piecemeal.

By 2020, the predominance of aquacultural activities will remain concentrated in Asian countries, particularly China. The steady depletion of high-seas fish stocks, coupled with the slow but progressive turn toward land-based cultivation of living marine resources, suggests that the high seas are likely to diminish somewhat in importance as a world source of fish. Krill fishing will not cause any significant growth in the global fishing effort.

The legal consequence is that extension of coastal state jurisdiction seaward into high-seas areas as proposed by unilateral national measures such as Chile's presential sea concept and Canada's national legislation are less likely to be necessary. Regarding creeping jurisdiction, the strong impression is that there will be less creep, and perhaps even a reversal of that creep. Most coastal states regard the 1982 LOS Convention's fisheries regime out to 200 n.mi. as sufficient. Serious rethinking will occur among Latin American governments, particularly Peru, about the 200-n.mi. territorial sea claims. Peru in fact, will likely adopt a 12-n.mi. territorial sea by 2000. Chile may not give up its notion of the presential sea, but will neither push nor enforce jurisdiction over that vast area. The clear trend is toward greater numbers of states ratifying the 1982 Convention, not fewer. The result will be a more stable, more universally accepted regime for high-seas fisheries.

Even so, close management of stocks that straddle jurisdictional boundaries must be continued to ensure that conservation and management measures taken by coastal states in their EEZs are not undermined. Straddling stocks and highly migratory species will be most susceptible to overfishing. Recent resolution of the peanut hole and

donut hole controversies, however, underscored by entry into force in November 1994 of the Law of the Sea Convention and international adoption of the 1993 FAO Compliance Agreement and the 1995 Straddling Stocks Agreement, strongly suggest the emergence of an internationally accepted legal regime for managing and conserving high-seas fisheries stocks.

The relationship between fisheries technology and international fisheries law will continue to be interdependent. As developments in technology progress, advancements in international ocean law will evolve. Law will attempt to keep pace with technology. Consequently, new fisheries technologies will greatly affect relevant international law and determine on what issues and in which ways the Law of the Sea will evolve.

For the foreseeable future, the international law for national jurisdiction and management over living resources in ocean space will be generally accepted. The 1995 Straddling Stocks Convention and the 1993 FAO Compliance Agreement corrected ambiguities, generalities, and vagaries left in the 1982 LOS Convention that related to important issues affecting national jurisdiction and enforcement of fisheries law. Once in force, these new agreements will serve as the critical infrastructure for directing international fisheries law well into the 21st century.

States will increasingly look to regional and subregional organizations to manage ocean space beyond the limits of national jurisdiction. Regional fishery organizations will become particularly important for setting quota limits on harvesting various species, authorizing measures to enforce those conservation restrictions, and furnishing dispute settlement fora for resolving contentious issues between members. This tendency toward regionalism and subregionalism is implicit in both the 1993 FAO Compliance Agreement and the 1995 Straddling Stocks Agreement, and will be a major consideration in how international fisheries law is applied in the next century.

Implications for the Coast Guard

The Coast Guard is the lead agency responsible for the enforcement of applicable Federal laws on, under, and over the high seas and

waters subject to the jurisdiction of the United States. [103] In this regard, the Coast Guard is specifically authorized and expected to "make inquiries, examinations, inspections, searches, and arrests upon the high seas and waters over which the United States has jurisdiction, for the prevention, detection, and suppression of violations of laws of the United States." [104]Among these laws are those which prohibit or restrict foreign fishing vessels from harvesting resources within the exclusive economic zone areas offshore U.S. territories.[105]

The National Marine Fisheries Service regulates fisheries within the U.S. EEZ, and the Coast Guard enforces these regulations at sea. Federal laws authorize the Coast Guard to enforce regulations specifically concerning the conservation of north Pacific halibut, the hunting of whales, the conservation of tuna, and the protection of high-seas fisheries, fur seals, and sea otters in the north Pacific. The Coast Guard is also responsible for the general enforcement of regulations concerning the protection and conservation of marine sanctuaries, coastal zone management, the regulation of U.S. fisheries out to 200 n.mi. from the coastal baseline under the Fishery and Conservation and Management Act of 1976, and conservation and resource protection measures in the Antarctic.[106]

Off-shore resource exploitation continues

Drilling and platform operations

International law

As defined by the 1982 LOS Convention, there are essentially two continental shelves. The first corresponds with the geological definition of continental shelf and extends to the outer edge of the continental margin. The second is legal, and corresponds to the coastal state's exclusive economic zone. Since the coastal state's jurisdiction

103. 14 USC 2 (1994).

104. 14 USC 89 (1994).

105. The 1976 Magnuson Act.

106. 16 USC 1851-1855.

in its EEZ includes rights to resources of the underlying seabed and subsoil, the doctrine of the continental shelf grants important additional rights only to areas of the continental shelf that extend beyond that 200 n.mi., up to 350 n.mi. from shore (Article 76). For the United States, this includes areas off its northeastern coast.

The coastal state has sovereign rights over the continental shelf for purposes of exploring and exploiting its natural resources. The coastal state does not, however, have sovereign rights over the continental shelf for purposes other than the exploration or exploitation of its natural resources. Natural resources are defined as the mineral and other non-living resources of the seabed and subsoil, as well as sedentary fisheries that are immobile or unable to move on that seabed.[107] Other states may not drill on the continental shelf of a coastal state without the latter's consent for any purpose, including the exercise of scientific research.

Within the EEZ, the coastal state has the exclusive right to construct and regulate the construction, operation, and use of artificial islands, and any installations used for economic purposes, provided that these structures do not interfere with use of recognized international sea lanes essential for international navigation (LOS Convention, Article 60(1) and (7)). The coastal state has exclusive jurisdiction over such artificial islands, installations, and structures, including jurisdiction with respect to customs, fiscal, health, safety, and immigration laws and regulations (Article 60(2)). Where necessary, the coastal state may establish safety zones not to exceed 500 meters around such installations or structures (Article 60(4)-(5)). Abandoned or disused structures must be removed by the coastal state in a manner that ensures safety of navigation in accord with international procedures.

The international law for drilling into the continental shelf has not yet been fully established. Only in recent years has it become technologically feasible (and economically desirable) to drill beyond 200

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107. The Submerged Land Act of 1953 defines "natural resources" to specifically include "oil, gas, and other marine minerals, and fish, shrimp, oysters, clams, crabs, lobsters, sponges, kelp, and other marine animal and plant life..." (43 USC Section 1301 (e)).

n.mi. on the continental shelf. The law affecting these activities will be revised and augmented by 2020, especially as states with wide margins such as the United States, Canada, Ireland, and the United Kingdom increasingly proceed to engage in such activities.

International law for the continental shelf will continue to evolve into the 21st century. Establishment and activation of the Convention's Commission on the Continental Shelf will go forward, and this Commission will become the legal forum for drafting new provisions affecting exploration, exploitation, and regulation of continental shelf activities.

As the law of the sea regime move forward, the U.S. Government will be under the obligation to submit information to and participate in the Continental Shelf Commission created under the 1982 Convention. This will contribute to regularizing the legal regime governing exploitation of offshore hydrocarbon resources.

Trends

The trend in using offshore continental shelf resources will remain strong worldwide in the coming two decades. Consequently, utilization rates of offshore drilling rigs and platforms will become stronger as well throughout the period to 2020. Worldwide demand is on the increase, being driven up by an increase in the number of contracted rigs in the Gulf of Mexico. Demand for semisubmersible rigs also increased in 1995–96, and will continue to do so over the next decade. Deepwater drilling programs in the Gulf of Mexico, the North Sea, Brazil, West Africa, and the Far East will have positive effects on rig demand over the next five years, especially for submersibles.

Offshore drilling activity will be driven mainly by oil and natural gas price expectations. Natural gas prices will tend to drive North American offshore drilling activity, including that in the shallow waters of the Gulf of Mexico. International offshore drilling activity and deepwater projects in the Gulf of Mexico will be more closely tied to oil prices.

In addition to oil and gas prices, technology will play an increasingly large part in the U.S. rig count, which will stay within the 700–1,000 range. Due to special seismic technology, fewer wells will be required to establish and develop reserves. Other advances in technology will improve the drilling process as well.

Advances in horizontal and directional drilling will continue to reduce the number of wells needed to access a reservoir effectively. More accurate measurements while drilling, as well as improved steerable downhole motors, will produce more efficient drilling operations. Advances in drill-bit effectiveness and durability will enhance drilling performance. New completion techniques will continue to improve recovery and reduce downhole problems.

As service companies continue to increase drilling efficiency and improve drilling technology, rig demand rates will drop in coming years. Offsetting this trend is likely to be an increase in the number of offshore continental shelf oil and gas fields considered economical for development given lower costs with the availability of more efficient tools and techniques.

Deep gas drilling will not offer significant opportunities over the next decade. There will be little interest in drilling below 20,000 feet, largely because plentiful supplies of natural gas are available onshore, at cheaper costs of development. Deeper, more expensive holes will remains less commercially attractive for the U.S. oil and gas industry.

Over the next two decades, offshore drilling operations will increase in importance for the United States as onshore oil production drops and/or lags in meeting domestic demand. This will be especially so as the U.S. Government becomes more concerned about increasing vulnerability to national economic security created by increasing dependency upon foreign imports of petroleum and natural gas to meet U.S. national energy demands.

Implications for the Coast Guard

Among its primary legal duties, the Coast Guard is mandated to enforce or assist in the enforcement of all applicable federal laws on, under, and over the high seas and waters subject to the jurisdiction of

the United States. To this end, the Coast Guard is authorized to administer law and enforce regulations for the promotion of safety of life and property on and under the high seas and waters subject to the jurisdiction of the United States (14 USC, Section 2 (1994)). The continental shelf areas offshore the United States, which encompass more than 700,000 square miles of submerged land areas and include Alaska and Hawaii, fall under U.S. jurisdiction and hence qualify as areas subject to law enforcement by the Coast Guard.

The Coast Guard has the authority under the Outer Continental Shelf Act to make and enforce regulations with respect to lights, warning devices, safety equipment, and other safety matters on artificial islands and installations. The Coast Guard is the only agency that inspects offshore structures for compliance with safety regulations. For all drilling and production operations begun after 1978, the Coast Guard is charged with requiring the use of the best available and safest technologies that are economically feasible.

Ocean thermal energy conversion is unlikely

The sun warms the oceans at the surface, and wave motion mixes the warmed seawater downward to depth of 100 meters. This mixed warm layer is separated from the deep cold water. The concept of Ocean Thermal Energy Conversion (OTEC) envisions capturing the sun's warmth at the ocean surface and harnessing the temperature differences of surface and cold, deep waters to generate energy.

Technically, the conceptual basis of OTEC seems simple. Warm seawater from the ocean's surface and the cold deep water below are pumped through a heat exchanger that employs a working fluid, such as ammonia, propane, or freon, in a closed cycle. The warm water vaporizes the working fluid, which turns a turbine, thus producing energy.

Any system for using solar energy is inherently desirable because the source of energy is vast, nondepleting, nonpolluting and free. Another very attractive feature of OTEC is consistency. The temperature contrast in the water is unaffected by the nocturnal interruption of solar energy, though it is affected by seasonal changes. OTEC elec-

trical generators, if feasible, could produce round-the-clock energy, which could be transmitted to ashore by cable.

Temperature contrasts must be 20 degrees C (36 degrees F), or greater to power OTEC heat engines. In the oceans, such contrasts occur only in tropical or subtropical regions. Yet, some of these areas are affected by cold ocean currents, particularly the Peru and California currents which carry cold water from higher latitudes toward the equator and interrupt the tropical-band water temperatures where the surface waters are sufficiently warm to that 20 degree C contrast.

A number of U.S. coastal areas have access to OTEC resources. The Gulf of Mexico is within the favorable area, and both Puerto Rico and the Virgin Islands have access to temperature contrasts of the Gulf-Caribbean area. The islands of Hawaii fall within the favorable area in the Pacific, as does the island of Guam.

In the Gulf of Mexico, a surface-to-bottom contrast of 20 degrees C is attainable in areas close to the Florida coast. Around Puerto Rico and the Hawaiian Islands, an even more desirable 22 degrees C can be found. Off Puerto Rico, greater contrast might even be obtained by siting a plant farther offshore and using bottom water from the greater depth. In Hawaii, steep continental slopes surrounding the islands make a 22-degree contrast quite accessible. The greatest challenge for both Puerto Rico and Hawaii is to bring that very cold water to the surface while not expending excessive amounts of energy in the process.

Despite the low conversion efficiencies that are inevitable when a small temperature difference exists on opposite sides of a turbine, prospects for development OTEC appeared promising in the 1980s, especially for Hawaii, Guam, Puerto Rico, and the Virgin Islands. In these cases, the resources are easily accessible, and the alternative is imported fuel oil for power generation. OTEC offers the possibility to give these areas energy independence and to offer greater prospects of economic development.

There are limitations to OTEC, however. Serious logistical problems must be overcome during plant construction and installation. An island undergoing OTEC development must obtain the infrastruc-

ture necessary to support this type of project, including harbors, airports, good roads, and communications systems. The population base must be compatible with the OTEC plant size. Additional fossil fuel must be imported to pump the seawater though the conversion system.

Two distinct markets could be available for OTEC: first, industrialized states and islands; second, smaller or less industrialized states with only modest needs for power or fresh water. Estimates suggest that small OTEC plants could produce 1 to 10 megawatts of electricity and some 1 to 9 million gallons of fresh water per day, enough to supply the fresh water needs of a less-developed community of 5,000–100,000 daily.

Trends

The physical factors affecting OTEC site selection, especially thermal requirements and seafloor bathymetry, will greatly restrict the number of desirable sites for OTEC systems around primary continents. Although floating OTEC plants might relax these constraints, neither the technology nor the intensive capitalization necessary to support these plant ventures will be commercially available to any appreciable extent in 2020. The best potential land-based sites for OTEC will continue to be island locations in industrialized states, especially Puerto Rico, Guam, and Hawaii.

So long as the cost of crude oil and other fossil fuels remains low, the development of OTEC technologies will be promoted more by government agencies than by private industry. Relatedly, so long as the cost of fossil fuels remains low, little economic incentive will drive the rapid commercial development of OTEC technologies. Before OTEC can be commercialized, however, a demonstration plant must be constructed and operated to obtain information required to design and build commercial systems, to quantify environmental impacts, and to secure confidence from the financial community and energy industry.

Conventional plants pollute the environment more than an OTEC plant would. The fuel for an OTEC system is free and unlimited, so long as the sun heats the oceans. But such arguments were not suffi-

cient to persuade the U.S. Government—in particular the Department of Energy—to continue its research into OTEC; that program was dropped by DOE in 1993, with the hope that the private sector would pick it up. But this hope has produced a "catch-22" situation that will continue to inhibit research and development of OTEC technology over the next two decades. The financial community remains reluctant to invest in new OTEC technology until it has been tested and produces a record of operation. Private industry cannot be persuaded that the prospects for OTEC are commercially viable, since there is no record of operation. But there can be no record of operation, so long as OTEC technology is not commercially tested and given a market opportunity to be viable. Thus, while experiments with OTEC technology will continue over the next two decades, OTEC systems will remain more a conceptual model than a significant contributor to energy production in the United States or the developed world.

OTEC will remain in the research and development phase so long as competing energy forms, both fossil and other, remain more economically attractive. This situation is likely to persist for the foreseeable future. Energy production in the United States will focus on discovering and developing greater reserves of hydrocarbon fuels on land and offshore, rather than on perfecting exotic forms of energy technologies. As a result OTEC systems will be neither commercially available nor much used for energy production in the United States or elsewhere by 2020.

Vessels grow in numbers, size, and speed (in commerce with the United States)

World seaborne trade patterns

Prospects for the international shipping industry are expected to be bright. As the U.S. economy recovers (slowly), and as the economic conditions in Japan and Europe improve, the shipping industry is correspondingly showing signs of recovery. Seaborne commerce accounts for over 90 percent of trade among nations, and today exceeds 3.5 billion tons per year.

For example, assuming an average annual growth of 3.3 percent, the total world trade (in 1990 U.S. dollars) is forecast to total about $58 trillion in 2020—up from $22 trillion in 1990. Assuming slower growth in the United States, its share of the global economy will fall from 24 percent to roughly 17 percent in the same time frame. The Clinton Administration predicts that nearly 75 percent of world trade expansion over the next two decades will come from emerging economies.[108] Many analysts expect Asia to become the world's largest consumer market.[109] The economies to watch are China, Taiwan, Hong Kong, South Korea, Brunei, Malaysia, Thailand, the Philippines, Indonesia, and India.

Natwest Securities (NatWest), a ship financier, suggests in its *May International Shipping Survey* that all sectors of the shipping market, especially chemicals and gas, should benefit from the projected upturn in economic activity.[110] Seaborne trade is forecast to double by the year 2011 in response to growing consumer affluence and increasingly international patterns of manufacture.[111] The UN Conference on Trade and Development (UNCTAD) forecasts that international trade in the cargo sector will rise by an average of 3.1 percent annually, reaching an estimated 5.071 billion tons.[112] Containerized and other general cargoes are projected to increase at 3.5 percent per year to 1.117 billion tons. Over the same period, annual growth for dry bulk and tanker sectors is forecast to expand to 18.8 and 2.0 billion tons, respectively.

Inter-Asian trade is expected to have the largest growth in seaborne trade. Major U.S. shiplines (e.g., American President, Sea-Land) are seeing a resurgence of finished goods to Asia. Exports from China to North America show double-digit growth, with significant growth

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108.Tim Minahan, "A New Wave in Shipping," *Purchasing*, June 6, 1996: p. 50.

109."Getting Set for China," *Fairplay*, January 4, 1996: p. 10

110.Ian Middleton, "A Little Sunshine," *Seatrade Review*, January 1996.

111.Charles Batchelor, "Survey—World Shipping: Bright at first, but unchangeable later," *The Financial Times Limited*, June 4, 1996: p 1.

112.*Journal of Commerce*, January 7, 1994, p. 1B.

from Southeast and Southwest Asia as well. Trading markets (import/export) with Brazil, India, and the former Soviet Union are also expected to grow, but not as high.

In general, world trade is expected to grow steadily and possibly double by the year 2011. There will be considerable growth in seaborne trade involving Asia-Pacific states and developing countries. As far as the United States is concerned, this should translate into an increase in exports of finished goods to Asia; more imports from China as well as increased grain exports to that country; and more trade in general with Southeast and Southwest Asia and with developing countries such as Brazil and India.

A large part of the increased global seaborne trade, especially involving Asia-Pacific states, will involve a growing number of the largest container ships in the realm of 4,800–6,000 teu. Various trade journals have even discussed an 8,000-teu container ship. In terms of speed, these large ships might operate up to and even beyond 25 knots. Although we did not uncover specific projections concerning the percentage of these larger container ships involved in trade with the United States, some U.S. ports seem to be responding to this trend and preparing for an increase in larger container ships by dredging deeper channels and strengthening intermodal services. Orders for container ships have confirmed the rapid rise in the popularity of containerized freight: tonnage doubled between 1990 and 1995.[113] Container carrying capacity on a worldwide basis is expected to grow by about 8 percent annually for the next few years.[114]

A report compiled by UK-based Ocean Shipping Consultants predicts a sharp increase in container traffic through the world's ports. The report, entitled "The World Container Port Market to 2010," stated that container traffic will reach between 306 million and 335 million teu by the year 2005.[115] Most of the growth is expected in Asia.

113."Increase in Orders For Merchant Ships," Europe Information Service: Transport Europe, March 19, 1996.

114.Allen Wastler, "Growth in Size, Number of Ships Obscures Picture for Rates, Ports," *Journal of Commerce*, May 12, 1995: p. 8A.

According to Lloyds' Shipping Register, order-books for ocean freight tonnage around the world rose by 6 percent in 1995, the highest level since 1977. This rise has been fueled by the expansion of trading activity in Japan and Southeast Asia. Also, Asian manufacturing centers are moving south, creating longer hauls for ships moving goods to and from the United States.[116] Ocean freight carriers, responding to predictions of strong growth in container traffic, are building bigger vessels that could significantly alter U.S. freight-distribution patterns. However, this growth trend is unlikely to continue unless growth in global trade is sustained. Because the bigger ships will call only at larger ports (discussed below), those ports will need to increase their relay and intermodal services.

From an Enforcement of Laws and Treaties (ELT) standpoint it will be arguably harder to track and inspect cargo because five or more companies could have cargo aboard one ship, often in the same containers. Also, if a MEP incident occurs, it will be harder for the Coast Guard to determine responsibility. And, as we will discuss in the next section, there is a traffic management problem in that the vessels are too big for many ports and channels.

Offshore traffic

The business of extracting oil and natural gas from under the Gulf of Mexico is booming again. The move into deeper water has far-reaching implications for the oil industry, especially for the service and supply segments. One of the reasons for the high utilization rate of offshore service boats (i.e., higher demand) is the age of most of the existing fleet. That means a significant proportion of the fleet is undergoing maintenance, and new vessels will be built to accommodate increased deepwater activity.

Forecasts for the growth in active offshore rigs between 1995 and 2005 range from 3.2 percent to 11 percent (most likely) to 18.4 per-

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115.Discussed in "Study Predicts Doubling of Box Traffic," *American Shipper*, April 1996: p. 103.

116.Allen Wastler, "Growth in Size, p. 8A.

cent.[117] This means more traffic to and from offshore rigs, and more offshore vessels being built. The Mineral Management Service (MMS) is responsible for federal regulation of exploration and production on the outer continental shelf; however, the Coast Guard inspects offshore supply vessels and crew boats that support rig platforms. Thus, for the Coast Guard an offshore boom means more SOLAS inspections of offshore platforms, and more inspection (or overseeing) of offshore supply vessel and crew boat construction.

What this all means for oil spills and Coast Guard cleanup is unclear. With these offshore oil platforms, larger oil tankers will be filling up at sea, which could mean that more oil will be spilled in the water during its transfer to ships (one of the main reasons for spillage today). A lot of oil in the water farther out could also mean a harder cleanup as the tide spreads the spilled oil. See the discussion on deepwater ports and lightering capabilities below.

Size of U.S. merchant fleet declines

U.S. shipping industry

U.S.-flag merchant shipping has floundered for decades. High-priced crews, taxes, and strict safety regulations have rendered the U.S. shipping industry uncompetitive with foreign flag fleets. The United States has an open shipping market (foreign trade, not domestic), which has given foreign vessels access to U.S. ports and cargo, and as a result the U.S. flag fleet has dropped steadily. In the domestic U.S. trade, the continued decline in the volume of oil shipped to the continental United States from Alaska's North Slope has squeezed the domestic tanker fleet. Also, the continuing decline in U.S. trading activities (as discussed above) is likely to undermine the financial stability of the U.S. shipping industry.[118]

117."Gulf of Mexico: The Move into Deeper Waters Gets Started," *Marine Log*, June 1996, p. 55.

118."Continuing Slide in US Trade Spells Bad News for Ship Lines," *Journal of Commerce*, April 17, 1996: p. 1B.

Today, 98 percent of all U.S. foreign trade is shipped by sea.[119] However, U.S. vessels haul less than 5 percent of the total tonnage and only 15 percent of cargo value.[120] Total U.S.-flag foreign trade tonnage, including imports and exports, is barely 3 percent of domestic tonnage. The U.S. oceangoing fleet is "old, small, and shrinking." Reflaggings and the scrapping of aging vessels reduced the U.S. flag merchant fleet to a little over 300 in 1995, out of 30,000 oceangoing vessels worldwide.[121] The number of U.S. flag tankers is projected to be 130 in 2000.[122]

However, the declining number of U.S. flag ships is not in itself necessarily a harbinger of the demise of U.S. shipping. As the number of ships has declined, cargo-carrying capability has increased. Faster vessels and innovative cargo-handling technologies result in increased productivity. However, most container ships moving to and from the United States are only 67 percent filled, slowing plans by some carriers to increase cargo-carrying capacity more. [123] (See table 10.) Further, the continuing slide in U.S. trade in 1996 has meant emptier ships for ocean carriers. The industry fears that this trend could have serious implications in shipping rates. Lower shipping rates will further consolidate the industry, and adversely affect shipbuilding construction.[124]

The factors that have caused the decline in U.S. flag shipping (U.S. labor costs, more stringent inspection standards, dwindling federal support for the U.S. flag fleet, and aggressive foreign competition) are not expected to change much, even by 2020. In fact, these factors

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119.*Free Use of the Sea. Essential for the National Security of the United States.* National Security Industrial Association, 1994.

120.Anderson. *Atlas of the American Economy.*

121.*Journal of Commerce,* Jan 8, 1996.

122.Statement by Rep. Gene Taylor (D-Miss) in *The Times-Picayune,* December 7, 1995.

123.About 17 million container slots were available on ships in 1995, and ships lifted the equivalent of about 11.5 million 20-foot boxes into their holds. See Michael Fabey, "Continuing Slide in US Trade Spells Bad News for Ship Lines," *The Journal of Commerce,* April 17, 1996: p. 1B.

Table 10. Percentage of capacity used on U.S. containerships[a]

Quarter	Imports	Exports
Q1/94	70%	57%
Q2/94	72%	58%
Q3/94	78%	58%
Q4/94	74%	60%
Q1/95	71%	64%
Q2/95	72%	63%
Q3/95	75%	61%
Q4/95	67%	62%

a. Source: Port Import/Export Reporting Services, On Board Review; Journal of Commerce.

could get worse. So further decline in the U.S. shipping industry is the most likely scenario for the U.S. shipping industry.

For example, the U.S. Department of Energy forecasts that domestic crude-oil production will fall by 25 percent between 1990 and the year 2000, and net imports of crude oil will increase by 44 percent.[125] As the Alaska oil fields are played out, the United States may have to import more oil from abroad (i.e., shifting transportation from U.S. ships to foreign ships). This means more supertankers with oil coming to the United States from the Persian Gulf and elsewhere, which could mean more offshore mooring platforms. More foreign ships in U.S. waters means more port-state certifications for the Coast Guard. These ships will have to comply with OPA-90 double-hull requirements. But many in the U.S. shipping industry (and the Coast Guard) fear that many foreign ships with foreign crews are of lower quality than U.S. ships with U.S. mariners. Assuming there is some

124. Shipping cycles work as follows: When rates are lowest, shipowners are reluctant to invest in new ships and banks are cautious. Weak cash flow and the shortage of capital depress ship market values and new ordering, while encouraging scrapping and lay-up. These actions diminish the supply of vessels. A cyclical rise in the economy pushes up transport demand and eventually freight rates rise. Normally it may take 2 or more years for rates to go from bottoms to highs. See Michael J. Hampton, "Shipping Cycles Revisited," *Seatrade Review,* January 1996.

125. Anderson. *Atlas of the American Economy.*

truth in this view it could mean more oil spills and therefore more cleanup work for the Coast Guard.

Jones Act[126]

The U.S. coastwise trade law, often referred to as the Jones Act, generally requires that U.S. built, crewed, owned, and registered vessels be used in U.S. domestic waterborne traffic (merchandise, passengers dredging, towing, and salvage). Because of coastwise laws, nearly 60 percent of the waterborne cargoes moving on U.S. waters in any year travel on American ships, built and maintained to U.S. standards, and crewed by trained and experienced American seafarers.

Currently, the U.S. domestic fleet comprises more than 44,000 vessels that carry over 1.1 billion tons of cargo (value of $222 billion in 1996 dollars) and 80 million passengers annually.[127] The domestic U.S. maritime industry represents: 78 percent of U.S.-flag merchant tonnage; 38 percent of U.S. tonnage in vessels >1,000 grt; 87 percent of all shipboard employment opportunities; 70 percent of projected U.S. shipbuilding opportunities; and 97 percent of all U.S. flag waterborne commerce.[128] (Although there are no specific statistics, the domestic U.S. maritime industry represents the bulk of Coast Guard marine safety work.) Energy products such as coal, petroleum, and chemicals account for more than 60 percent of total inland waterways tonnage.

Although repeal of the Jones Act is not probable, there is some legislative and business support for it. We have chosen to consider such an event as a contingency rather than a trend. Repeal of the Jones Act would severely reduce U.S. shipping and shipbuilding by opening up most of the market to foreign shipbuilders and operators. Although international safety standards have been tightened in the past years, higher operating and insurance costs would place U.S. shipping com-

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126.This does not include the USN's some 128 logistical support vessels under the MSC, and the additional 92 held in Ready Reserve. Twelve additional Sealift vessels are being built for the Navy.

127.Anderson. *Atlas of the American Economy.*

128.FDCH Congressional Testimony before House on June 12, 1996.

panies at a disadvantage similar to that suffered by the U.S. flag international operators. U.S. companies in the cruise industry and in cargo/oil transportation have for years registered their vessels in places such as Liberia to remove their fleets from close scrutiny by U.S. regulatory bodies.[129] By avoiding U.S. standards, these owners can save hundreds of thousands of dollars annually on each ship.[130]

For the Coast Guard, repeal or reduction of the Jones Act would virtually kill flag-state inspections (e.g., almost no U.S. ships to inspect), while signalling a dramatic increase in port-state certifications. Because many foreign vessels are less well maintained and manned than U.S. ships, the probability of accidents (spills or collisions) could potentially increase. There could also be more "rejected" foreign merchant vessels waiting to be repaired. This could suggest more congestion in ports, and therefore more repair work for U.S. yards.

U.S. shipbuilding

At present, U.S. participation in the global shipbuilding market is estimated to be on the order of $33 billion a year. This is only about 1 percent of the total world market, because U.S. efforts to penetrate the global commercial market have been hampered by foreign government shipyard subsidies (and higher costs in the United States). In fact, most of the U.S. flag oceangoing fleet is foreign built.

U.S. shipyards are making significant capital investments to improve their facilities and increase their productivity. OPA-90 requirements to retrofit existing tanker tonnage and build new tankers with double hulls may provide opportunities for U.S. shipyards. The U.S. shipbuilding industry has already begun to benefit from these requirements. Table 11 shows that in 1995, the U.S. was 23rd, with only 0.45 percent of the world gross tonnage.[131]This compares with 0.17 percent of the gross tonnage in the world order-book one year earlier.

129.U.S. ships are operated by licensed, college-educated officers who are U.S. citizens. Every U.S.-flagged ship undergoes two, extensive regulatory inspections every 24 months.

130."Taking a Risky Route," *The Orlando Sentinel,* May 20, 1996: p. A12.

Table 11. World shipbuilding order-book (December 31, 1995)[a]

Country	% gross tonnage
S. Korea	30.26
Japan	29.70
Germany	4.95
Poland	4.48
Italy	4.22
China	4.15
Romania	2.50
Taiwan	2.41
Spain	2.02
Ukraine	1.95
USA	0.45

a. Source: Lloyd's Register.

The 1995 U.S. order-book shows a 96-percent increase in the gross tonnage on order compared with last year.

In 1995, the U.S. shipbuilding industry received two new orders for the construction of four oceangoing commercial ships and one order for four tanker reconstructions.[132] These new orders represent the largest number of commercial ships ordered from U.S. shipyards in a single year in almost two decades.[133] During the first two months of 1996 an additional order for five product tankers (for Greece) was received by a U.S. shipyard. These vessels represent the first U.S.-flag product carriers to be constructed in the United States in 11 years. All told, American shipyards are now building more commercial ships than they have in more than a decade, and for the first time in 30 years the United States is exporting commercial vessels.[134] Table 12

131. *Outlook for the U.S. Shipbuilding and Repair Industry 1996.* Office of Ship Construction Division of Cost Analysis and Production, April 1996, p. 2.

132. On May 12, 1995, Avondale Industries executed a contract for the reconstruction of four U.S.-flag product tankers that will comply with the double-hull requirements of the OPA-90.

133. *Outlook for the U.S. Shipbuilding and Repair Industry 1996.* April 1996, p. 8.

lists the number of building orders for U.S. commercial oceangoing ships since 1975.

Table 12. U.S. commercial shipbuilding order-book

Year	No. of ships	Year	No. of ships
75	77	86	7
76	71	87	0
77	51	88	0
78	59	89	0
79	62	90	3
80	46	91	3
81	35	92	1
82	21	93	1
83	13	94	3
84	14	95	10
85	11	96	15

In recent months, the U.S. Government has been under considerable pressure to support the declining U.S. merchant fleet through greater subsidies. In addition to making arrangements for placing U.S. officers and engineers on vessels under foreign flag, Congress passed a subsidy program for $1 billion over ten years to maintain a U.S. merchant fleet, one that will be available to transport equipment in times of war. To receive subsidies, operators must use U.S. crews and fly the U.S. flag. Also, the five-year MARITECH program encourages U.S. shipbuilding and the application of new technologies. Such programs could continue well into the future. Still, these subsidies and other forms of support will likely only slow the decline of the U.S. merchant fleet, given foreign competitiveness and the rate at which aging U.S. vessels are being scrapped.

134."Maritime Administrator Lauds Reemerging U.S. Shipbuilding Industry at First American International Exposition," Office of the Assistant Secretary of Public Affairs, U.S. Department of Transportation, April 11, 1996.

In summary, the U.S. shipbuilding industry has experienced some recovery and growth. But these gains are modest when considering the very competitive nature of world shipbuilding, and the limited U.S. position therein. Continued modest growth is certainly possible for the U.S. shipbuilding industry. However, the larger shipbuilding nations are better positioned to take advantage of the growth expected in tanker shipbuilding described earlier. Nonetheless, the more U.S. construction, the more inspections the Coast Guard will presumably be called upon to do. If the Coast Guard retains its marine inspection mission, it could manage any increase in U.S. shipbuilding with its current program.

Consolidation of the U.S. shipbuilding industry, which is one commonly accepted forecast, may also affect the Coast Guard. As of January 1996, 16 shipyards are considered to be part of the U.S. major shipbuilding base;[135] some estimate that after the industry has finished consolidating there will be only eight. For the Coast Guard this means less journeyman training and fewer opportunities for marine inspectors.

Number of HAZMAT carriers (in commerce with the United States) grows

Unlike most areas of bulk shipping, the chemical market has yet to reach maturity; thus, analysts see considerable room for growth in the coming years. Shipowners are benefiting from the surge in chemical tanker freight rates. This surge in rate levels is attributed to the strong tanker demand and weak tanker supply. Chemical tanker freight rates are set to continue to rise through this year and 1997, before beginning to level out in 1998, according to a recent study from Drewry.[136] Drewry also expects operators to face escalating costs to meet ever

135. They are: Bath Iron Works, Electric Boat, BethShip, Newport News, Intermarine, Alabama Shipyard, Halter Marine, Ingalls, Avondale, AMFELS, National Steel and Shipbuilding, Gunderson, Tacoma Boatbuilding, Todd Pacific, Fraser, and Marinette Marinbe.

136. "Chemical shippers sea clear horizons," *ECN-European Chemical News*, February 12, 1996: p. 33.

more stringent safety and environmental regulations and rising operating costs in general. Organic chemicals represent around 70 percent of total demand for chemical tankers, inorganic acids account for 12 percent, and caustic soda solution and natural oils each account for around 9 percent.[137]

The medium-term outlook for chemical shippers looks promising. Many changes are expected in the chemical carrier sector because it is not as mature as the other bulk shipping sectors. Trade will generally become more diffuse with the advent of both additional producers with export capacity and additional downstream markets.

Over the next five years the highest rate of growth will be seen in commodity and specialty chemicals sectors; they will represent more than 60 percent of chemical cargoes in the late 1990s, compared with some 55 percent at the start of the decade. Drewry expects organic chemical trade to rise by 5.0 percent per year and inorganic chemical trade to remain at 1995 levels.

The most important element of the commodity chemicals trade is continuing demand from the Far East. With much new chemical industry capacity being built in the emerging Asian nations, new trade patterns will emerge. Drewry identifies two such patterns:

- The continued expansion of intra-regional trade of base and intermediate chemicals within Southeast Asia
- An expansion of the trade of specialty chemicals from Europe and the United States to Asia. [138]

This leads to an increase in demand for small-to-medium-sized parcel tankers to operate on the Southeast Asian trade routes, and larger, more sophisticated parcel tankers to operate on the long-haul routes from North America and Europe to Southeast Asia. There is room for the U.S. share of the world market to increase, while Europe's slice is unlikely to change.[139]

137.Joanna Pegum, "Change Ahoy for Chemical Shipping," *ECN-European Chemical News,* July 17, 1995: p.14

138."Chemical shippers sea clear horizons," p. 33.

The demand for chemical tankers will continue to grow over the next five years, given the relatively young profile of the chemical tanker fleet—i.e. new tanker building will exceed scrappings.[140] Experts predict that tanker supply (i.e., new construction) will increase by 11 percent to the year 2000, or 1.6 percent per year. This equates to an expansion from 18 million dwt at the end of 1994 to 20 million dwt by the end of 2000. However, this increase will remain insufficient to meet the high demand for chemical tankers.[141]

Chemical or HAZMAT shipping is a major concern for the Coast Guard. A chemical or HAZMAT accident would be the one incident of national significance that the Coast Guard is least prepared to deal with. The risk here is a function of the volume of traffic (again predicted to grow); the lethality of the chemical (always bad); its volatility; the topography, size, and location of population centers (mostly Houston and its environs); and weather conditions.

Liquefied petroleum gas (LPG)

As with chemicals, the United States is the leader in LPG technology, which is highly automated, research oriented, and capital intensive. The United States, Western Europe, and Japan consume about two-thirds of LPG, but increasing demand from South Korea and Southeast Asia has stimulated LPG's market growth. LPG trade has witnessed an annual average growth rate of 6.7 percent since 1980, and is expected to continue growing, albeit at a lower rate. As table 13 shows, it is expected to reach 45.35 million metric tons by 2000 (up from 39.30 million metric tons in 1995).

Table 13. Seaborne trade in LPG and chemical gases[a]

Year	LPG	Ammonia	Ethylene	Propylene	Butadiene	VCM[b]
1995	39.30	12.07	1.37	0.87	0.84	1.13
2000	45.35	13.81	1.41	0.97	0.84	1.1

a. Source: Drewry Shipping Consultant.
b. Vinyl chloride monome.

139.Pegum, "Change Ahoy," p.14.

140.Pegum, "Change Ahoy," p.14.

141."Chemical shippers sea clear horizons," p. 33.

The United States is the single largest producer of LPG, although nearly all of its 30 to 32 million metric tons per year output is used in the domestic market. The LPG market in the United States is mature, with growth rates of 2 to 3 pecent per year the norm.

Growth in international trading of LPG has resulted in increased LPG shipbuilding.[142] However, the expansion in the fleet during the most recent building period has been considerably in excess of changes in demand. Current surplus capacity in the LPG fleet is estimated at 20 percent. Indications are that the size of the fleet is about to level out. Drewry predicts that the current fleet of 11.7 million cubic meters in 1995 will reach 12 million cubic meters in 2000 and then level out.

The United States is likely to remain the industry leader in LPG technology. Thus, as emerging economies either discover new fields or have increased demand, U.S. companies will likely supply much of the equipment, technology, and knowledge needed. Thus, either U.S. personnel and/or vessels will be involved in this growing trade, but it shouldn't appreciably change any Coast Guard missions. However, as more of these highly dangerous ships transverse U.S. waters, the possibility of an accident increases. Again, this is a case of a potential deadly "incident of national significance" for which the Coast Guard may not be prepared.

Number of barges and tugs grows

Barges and tank barges

Strong production at the nation's petrochemical plants is helping fuel the demand for tank barges. Present demand exceeds the available number of barges, and future increases in the volume of chemical shipments will heighten pressure to make more barges available. OPA-90 requirements (all tank barges must be double-hull by 2015) plus the need to retrofit existing barges with vapor-recovery systems have increased the tank barge business at second-tier shipyards. The

142. *The Oil and Gas Journal*, January 9, 1995: p. 24.

tank barge fleet now numbers 2,870. Of these, 500 are single-hulled and must be replaced by 2015 as a result of OPA-90.[143]

To meet additional volume in commodities such as grain and coal, some industry experts are predicting that as many as 10,000 additional barge loads annually will be needed. Because fewer dry-cargo barges have been available in recent years, this projected additional tonnage should create a demand for the construction of new barge units.[144] These new buildings would be in addition to the normal replacement of barges that are retired because of age.

More construction of any type of ship means more flag-state inspection—if the Coast Guard is still doing this—and more licensing of barge drivers. However, there is nothing to suggest that the Coast Guard mission with this work would change marginally.

Tow and tug boats

The nation's fleet of 1,233 towboats (as of August 1994) is aging; almost half of them have been in service longer than 20 years. Table 14 shows the ages of towboats currently operating on U.S. waterways.

Table 14. Age of towboats on U.S. waterways

Age in years	No. of towboats
<5	28
6–10	52
1–15	301
16–20	245
21–25	202
>25	395

Estimates are that the towboat market will expand in the next few years. This growth is expected to continue, largely due to the benefits

143. *Outlook for the U.S. Shipbuilding and Repair Industry 1996*, April 1996, p. 24.

144. OPA-90 affects foreign tankers entering U.S. ports as well.Ibid., p. 23.

from healthy grain sales and the passage of NAFTA. Recent accidents, such as the one in which a tug ran into a railroad bridge, have led some to speculate that the Coast Guard's role with this unregulated waterborne industry will change. (Towboats are not required to be inspected.)

Number of passenger vessels grows somewhat

The Cruise Lines International Association (CLIA) reports that 31 new ships are contracted for or are planned to be added to the North American fleet by 1999 (see table 15).[145] At the turn of the century, ship orders will significantly decrease after the current crop of new-buildings are fielded and cruise lines monitor absorption rates for their new fleets.[146]

Table 15. Growth in North American cruise industry (contractual and planned)[a]

Year	No. of lower berths	Growth (%)
1995	104,727	+0.7
1996	116,711	+11.4
1997	128,783	+10.3
1998	143,901	+11.7
1999	144,297	+0.3
Average		+7.0

a. Source: CLIA Five Year Capacity Analysis, January 1996.

Industry executives have varying opinions on the future prospects of passenger ship new-buildings. Some anticipate a temporary decline, in view of the large number of vessels currently on order. In the past,

145."CLIA Still Sees Plenty of Room for Growth in North American Cruising," *Marine Log*, June 1996, p. 60.

146.Ernest Blum, "Shipping Analyst Predicts Cruise "Price Slide," *Travel Weekly*, April 4, 1996: 12.

the realities of too many passenger ships and too few customers have had a sobering effect on this sector of the marine industry.

On the other hand, many believe that the rate of new-buildings will increase in light of the potential for growth of the cruise business.[147] It is projected that as many as 7 million people will cruise from American ports by the year 2000, up from 5 million in 1995.[148] These analysts believe that globally the cruise industry will continue to support an additional four to six ships each year and will capture a greater share of the recreation and vacation market.[149] If necessary, cruise lines are expected to decrease their rates due to overcapacity and underuse.

We were unable to completely resolve these differing opinions. Nor did we uncover data indicating what percentage of this growth will be concentrated in U.S. waters. Analysts state that the Caribbean traditionally has provided the greatest growth and stimulus to the cruise industry. The port of Miami, one of the world's largest cruise ports, may likely experience an increase in cruise vessel traffic and in the number of cruise passengers.

The industry is also considering much larger ships (tonnage and passenger capacity). For example, Carnival Cruise Lines is planning to purchase additional 100,000-gt ships. There has also been considerable discussion concerning *Phoenix World City*, a planned 250,000-gt ship capable of carrying 5,600 passengers. The Coast Guard will remain an important player as safety standards and response plans are developed for such large-capacity vessels.

Gambling/gaming vessel numbers remain stable

Currently, riverboat gambling is legal in at least nine states and under consideration in five more. However, no states have legalized river-

147.Paul Doughty, "Berths, more Berths," *Motor Ship*, Nov 1995: p. 23.

148.Susan Parker, "Cruise Ship Orders Continue Unabated," *Motor Ship*, May 1995 p. 25.

149.Ibid.

boat gambling since 1994. We have found no evidence of an intended substantial increase in the number of riverboat gambling ships. In the past, industry predicted a sharp increase in the number of vessels, especially on the Mississippi. Instead, the market was saturated with too many boats and not enough passengers. As a result the riverboat gambling/gaming industry saw profits fall.

In response to declining profits, the riverboat gambling industry has begun to make changes. First, it is emphasizing fewer, but larger and more luxurious vessels, capable of handling between 3,000 and 4,000 passengers. In the Southeast United States, the industry is considering off-shore gambling vessels to escape state regulations and benefit from the growing popularity of cruise vessels. The industry is also beginning to focus on dinner and entertainment cruises. (It is not clear whether such vessels would replace or exist in addition to gaming vessels.)

The Coast Guard is affected by some problems associated with gambling vessels: these vessels operate in busy waterways; passengers, who may be intoxicated, are often unaware of the ship's movements; and passengers are not instructed on safety procedures. With these high-capacity vehicles, the Coast Guard must deal with the very real possibility of multiple casualties. This is especially a concern as gaming vessels move to beyond 3 miles off the coast—the farther out the ship is and the more people it has aboard, the more difficult the rescue will be. Basically, with passenger vessels, as the number of ships and the number of shipriders increase, so does the probability of an accident.

Containerized traffic is consolidated in fewer, deeper-draft ports

There is a clear trend in favor of larger, deeper-draft vessels, especially container ships in the range of 4,800 to 6,000 teu. There is talk of even larger container ships, in the range of 8,000 teu. But analysts seem confident that the next-generation container ship will be in the range of 6,000 teu and will draw up to 46 feet.

Several ports in the United States are taking this trend seriously. Currently, only a handful of ports are able to handle ships in the range of

6,000 teu. The deepest-draft ports, such as the ports of New York and New Jersey, Los Angeles, and Long Beach, have begun major dredging projects (N.Y. to more than 50 feet and L.A. to 63 feet). Oakland has plans to expand to 45 feet.[150]

In addition, these larger ports are the only ones capable of handling the huge amount of containerized cargo and transporting it efficiently. The ports of New York and New Jersey, Los Angeles, Long Beach, Seattle, and Tacoma have all begun major renovations to handle increased intermodal traffic.

Finally, analysts point to alliances between major carriers and these "megaports" or "superports" in order to trim shipping and service costs as well as to ensure the efficient transport of cargo. Because these new, larger container vessels will call on fewer ports, some analysts believe that a handful of ports will become the primary entranceways and larger ports in the United States. The ports most likely to benefit and grow are New York/New Jersey, Los Angeles, Long Beach, Seattle, Tacoma, and Oakland—more so the West Coast ports, because trade with Asia is expected to grow faster. All of these ports have already begun major renovations to help handle the new traffic and deliver the freight of inland ports.[151] Forcing most trade into fewer ports could cause traffic management problems, which would clearly involve the Coast Guard.

Another trend, however, may reduce the traffic at some U.S. ports: Some states (e.g., California and Washington) are becoming more actively involved in marine safety issues, such as inspections and environmental protection. It is possible that these states require traffic in their ports to abide by additional regulations or to pay additional fees. This could force some companies to ship goods to the United States indirectly, taking advantage of the North American Free Trade Agreement (NAFTA). Cargo bound for the U.S. could be shipped through neighboring countries' ports, which are not under U.S./Coast Guard jurisdiction for marine safety matters (and are less expensive).

150.*Purchasing*, June 6, 1996, pg.49.

151.Minahan, "A New Wave in Shipping," p. 49.

There has been some debate as to whether developments in ship size and draft will actually affect the ports, or whether port size and channel depth will act to restrict future ship development. The consensus in the industry seems to be the former. Already, U.S. and foreign ports with the deepest draft and most capable intermodal services are positioning themselves to accept and service larger containerized vessels. Hans Ludwid Beth, Chairman of the Port of Hamburg, has been quoted in *The Journal of Commerce* as stating, "Ports, be they in Asia, America, or Europe, are not in the driver's seat....We have to accommodate what the carriers do."[152]

Traffic is congested in certain ports

As noted above, given the trend toward the consolidation of containerized cargo in fewer, deeper-draft ports—due to the increasing size of container ships and draft requirements and the need to efficiently transport large amounts of intermodal cargo—many expect traffic congestion to be an increasing problem.

This trend suggests a growing need for advanced vessel traffic services, such as a system integrated with satellite navigation and other technologies, for those ports that have more container traffic.

No new deep-water ports are added; ships continue to rely on lightering

The Louisiana Offshore Oil Port (LOOP) is the only offshore deep-water port in the United States for a very practical reason: despite the environmental benefits LOOP offers by being far from shore, it has failed to generate enough commercial revenues to make it profitable. LOOP has steadily lost money since it began operations in 1981. Also, environmental rules for waters under U.S. jurisdiction (oil tanker traffic and reception facilities) have become increasingly strict since the 1989 *Exxon Valdez* disaster. These rules, in addition to LOOP's uninspiring economic record, have discouraged prospects for constructing additional deep-water ports.

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152. *Journal of Commerce*, May 12, 1995, p. 8.

The legislative emphasis on environmental protection and liability for oil spills will dissuade investors from supporting the construction of additional deep-water port facilities. Federal subsidies for such projects are also unlikely, given increasingly tight fiscal constraints.

Furthermore, the United States is trying to reduce its reliance upon foreign oil imports; thus, the U.S. domestic petroleum industry is encouraged to drill more wells farther out on the continental shelf in the Gulf of Mexico. The 1995 Outer Continental Shelf Deep-Water Royalty Relief Act provides substantial incentives for oil and gas production in the Gulf of Mexico by temporarily eliminating royalties on certain deep-water leases. The trend will be toward using gas and offshore oil, decreasing imports, and possibly increasing production in Alaska to make up the shortfall created by high demand. Thus, the economic climate in the United States should not be conducive to the construction and operation of additional deep-water ports offshore.

In the last several years, the Port of Corpus Christi has developed a "Safe Harbor" concept, which is a scaled-down, more economical, and less regulated version of LOOP. The concept centers around a deep-water port, closer to shore than LOOP, where tankers pump oil ashore using shipboard pumps rather than the more costly pumps required by longer pipelines. Cost-benefit analysis of the concept revealed that it would take 20 to 25 years to break even; therefore, further development was suspended indefinitely.

Because offshore ports are prohibitively expensive and so tightly regulated, lightering of oil tankers should continue as the most cost-effective means of transporting oil ashore. In the past, many felt that having an increased number of very large crude carriers (VLCCs) made offshore ports more affordable, because of the number of lightship transfers required for each VLCC. However, the number of VLCCs carrying oil into the United States has not increased as expected. (VLCCs are used primarily to carry Persian Gulf oil to the United States and elsewhere. Smaller, mid-weight tankers are used to carry oil from Alaska, the North Sea, and South America—and we are getting more oil imports from these areas and less from the Persian Gulf oil than formerly.)

For the time being, port and industry officials see lightering as a safe and efficient means of transporting oil ashore (compared with expensive options such as LOOP and other offshore concepts). The Coast Guard may revisit the location and number of lightering zones in the Gulf of Mexico in the wake of the *Mega Borg* incident—an accident involving a lightship transfer of a petroleum tanker. However, lightering will remain important, and lightship requirements will be contingent upon the strength of the petroleum industry in general.

Long-term intermodal growth occurs

There is a trend toward greater cooperation among the primary means of transportation involved in intermodal commerce (shipping, rail, trucking). Specific forms of cooperation include better tracking software for intermodal cargo and a concerted effort by rail lines to ensure faster, more efficient transport. Traditionally, trucks have been the most expensive form of transport but also the most efficient. Rail has traditionally been described as the least efficient but cheapest. Shipping companies have described themselves as combining the efficiency of trucks and the cost-effectiveness of rail.

We are also seeing a trend in which shipping and rail recognize some of their combined cost efficiencies, and attempt to break into shorter-haul markets. Generally, these two forms of transportation are reserved for longer-haul traffic (over 600 miles). We found few data to use in predicting how effective this attempt will prove. Nonetheless, analysts have already predicted a 10-percent growth in intermodal volume (and an 8-percent growth in revenue) in the short term. Steve Lewins, Vice President of Gruntal & Co., predicts a 50-percent growth in intermodal transport in the next ten years.[153]

Oil traffic grows in short term, declines in long term

In the near term, our dependence on crude oil (both domestic and foreign) will grow and force an increase in oil imports and in exploration in the Gulf of Mexico. However, in the long term, our depen-

153.Patrick Fitzgerald. *Chemical Marketing Reporter,* June 10, 1996: p. SR5.

dence on oil will decrease, due primarily to a greater emphasis on natural gas and the development of fuel cell technologies and other more fuel-efficient technologies. Thus, in the long term, the amount of oil traffic in international and domestic commerce will decrease.

Trends concerning U.S. dependence on crude oil (i.e., fuel cells, natural gas) are dealt with separately in this study.

Environmental trends

Coast Guard-relevant environmental trends include the following:

- Arctic shipping routes could increase.
- Antarctic activity changes little.
- Global warming effects continue.
- Concern over oil pollution increases.
- Ocean dumping declines.
- Concern for and protection of endangered species continues.
- Emphasis on sanctuaries and "zoning" for maritime stewardship increases.

Arctic shipping routes could increase
Antarctic activity changes little

Arctic activity

The Arctic Ocean is essentially a deep, ice-covered mediterranean sea, rimmed by northern portions of continental Europe, Asia, and North America. The smallest of the world's oceans, it lies mostly north of the Arctic Circle, and covers an area exceeding 14 million square kilometers. Most astronomers place the boundary of the arctic region at the Arctic Circle (latitude 60° 30' north), although others regard the edge of the region to be along the 10° C (50° F) isotherm. The region's polar climate is characterized by persistent cold. Winter is characterized by continuous darkness, clear skies, and cold and stable weather conditions. Summer has continuous daylight, and damp and foggy weather with periods of rain or snow. During winter, ice in the Northern Hemisphere freezes over an area about twice the size of the United States.

Surrounded by land masses, the Arctic Ocean opens in the southeast to the North Atlantic and in the southwest to the Bering Sea as the limited gateway to the Pacific. In contrast to the polar south, arctic sea

ice is hemmed in by land during the winter months. The channels into the Atlantic and Pacific oceans are important shipping routes serving large populations and areas with considerable mineral reserves. The main shipping ports in the Arctic are Churchill (Canada), Murmansk (Russia), and Prudhoe Bay (United States).

The central surface of the Arctic Ocean is covered by a perennially drifting polar ice pack that averages three meters in thickness, although pressure ridges can be three times that size. The ice pack is surrounded by open seas in the summer, but more than doubles in area as it freezes over during the winter to extend to the surrounding land masses. The ocean floor is 50 percent continental shelf, more than any other ocean.

Economic activity in the Arctic is limited to the exploitation of natural resources. Considerable land-based mineral resources are in the region, the most valuable of which are gold, tin, diamonds, nickel, copper, coal, and vast amounts of oil and natural gas. Arctic marine life includes fish (cod, salmon, and char) as well as seals, whales, and walruses.

The ocean environment in the Arctic is infested with ice islands and icebergs around western Greenland and northeastern Canada. The region, virtually icelocked from October though June, has a fragile ecosystem that is slow to change and thus slow to recover from abrupt disruptions or damage. A disastrous shipping accident (such as rupture of an oil tanker) would likely cause long-term losses in fish and wildlife resources, and destruction of the arctic environment. Such an ecocatastrophe could severely affect native community activities in the region, and could result in population dislocations, or even declines.

The Northwest Passage provides a shortcut across the Western Hemisphere from the Northern Atlantic, up the west coast of Greenland, through the Northwest Territories, and into the Beaufort Sea. The route has been transited fewer than 50 times, however. During summer, smaller ships can get through the shallow southern route when melting ice breaks up. Larger vessels stick to the deeper northern route, where they must break their way through heavier ice. By

November the passage is frozen. Currently, no cargo ships traverse the entire passage.

From March to November, Russians use the Northeast Passage as a primary shipping route for bulk cargoes. This Northern Sea Route entails a marine passageway that follows the Eurasian coastline between the Atlantic and Pacific oceans, cross four arctic seas (the Kara, Laptev, East Siberian, and Chukchi) and extends a distance of some 2,200 to 2,900 miles, from the islands of Novaya Zemlya in the west to the Bering Strait in the west, depending on which way it is navigated.

The Northern Sea Route offers distances between the north Pacific and European ports that are 35 to 40 percent shorter than the traditional routes through the Suez and Panama canals. Transit speeds from July through October are competitive with those attained on the southerly routes, although slow speeds during the rest of the year offset the savings in distance. Navigational difficulties are considerable in these northern waters due to bitter weather conditions, short daylight season, ice-infested waters, and isolation.

The challenging physical environment of the far northern arctic waters requires further development and refinement of new technologies for ship design, as well as for ship operations. Over the past 40 years, application of modern marine technologies for designing of new polar ships has made it possible to travel to remote regions thought even in 1980 to be impenetrable. Polar ships have become larger, stronger, and more powerful, with improved propulsion systems and greater ice-breaking capabilities.

Finland and the Soviet Union have made the greatest contributions to polar shipbuilding, especially in developing icebreaker design and nuclear propulsion systems. Canada and the United States have also contributed to key advances in polar navigation technology, including hull and bow design, application of gas turbines, and the controllable pitch propeller.

Investment in building ice-class ships is considerable, and vessels are less efficient and more costly to run in open water than conventional

ships. To offset greater costs, ship owners must rely on year-round service.

The Russians officially opened the Northern Sea Route to foreign use in July 1991. Two marine operations headquarters direct operations such as scheduling, route assignment, navigational support, and pilotage. Even so, genuine skepticism remains as to whether the Russians can reorganize operations and develop enough continuity that foreign shippers will have confidence in their arctic routing system. It is hoped that such confidence might lead to increased use of the North Sea Route, foster greater stability and confidence, and in turn attract even more international traffic. However, social instability in Russia remains a large impediment to development of the Northern Sea Route. Labor discontent, currency devaluation, cutbacks in personnel and services, and the inability to maintain the fleet and navigation are all problems that directly affect future development. These factors produce a climate of uncertainty for potential users of the route, which correspondingly diminishes foreign interest. For the Northern Sea Route to maintain an economic advantage over other route options, the Murmansk Shipping Company and the Far Eastern Shipping Company must be more willing to offer more secure rate guarantees.

In brief, northern shipping routes will be used more only if they are shown to have an economic advantage. Development of hydrocarbon and other mineral resources in the Arctic could make it commercially worthwhile to transport resources through the northern routes. This increased passage by commercial vessels could serve as a confidence-building measure to attract even more vessel traffic through these routes. The key to successful operation of these routes, however, will remain Russia's internal political stability and domestic economic viability.

Antarctic activity

The Antarctic consists of a high, perennially ice-covered continental land mass that is surrounded and estranged from the rest of the world by the windswept, frigid expanses of the Southern Ocean. The political boundary of the Antarctic has been set by the 1959 Antarctic

Treaty as that region south of 60° south latitude. Scientifically, the more appropriate demarcation line is the Antarctic Convergence, a relatively narrow circumpolar zone caused by the northward-flowing Antarctic's cold surface water impinging upon, and plunging below, the warmer, southern-moving subantarctic surface waters.

The continent of Antarctica occupies 9 percent of the planet's surface and is surrounded by varying amounts of sea ice. This sea ice plays an important role in the ocean-atmospheric climate system. It also affects research and economic activity there, because it affects access to the continent by sea. The extent of sea ice varies considerably with seasons and geographic location. The freezing season begins in March and ends after September or early October.

This antarctic sea ice expands and contracts according to the seas. In summer, the ice is some 2.6 million square kilometers (or 1 million square miles). In winter, the antarctic sea ice expands out from the continent to encompass an area exceeding 20 million square kilometers (7.75 million square miles), about 8 percent of the Southern Hemisphere. This ice pack reaches as far north as 56' south latitude in the Atlantic and 64° south latitude in the Pacific. The growth of antarctic sea ice effectively doubles the size of the continent from 18 million square kilometers to 34 million square kilometers (or 7 to 13 million square miles). Seasonal ice decay occurs rapidly from October through January.

Antarctica has been regarded for 40 years as a giant outdoor laboratory, and is attracting increased attention as scientists attempt to discern early warning signs of mankind's use and abuse of the planet. International cooperation is essential for both scientific research and logistical support.

The diversity and extent of Antarctica's mineral resources have not been determined. Geologists have discovered trace amounts of copper, lead, zinc, gold, and silver on the antarctic peninsula; chromium, platinum, iron ore, petroleum, and natural gas are almost certainly present, but have not yet been discovered. Exploitation of these mineral resources is not permitted for those states party to the 1959 Antarctic Treaty.

Politically, the antarctic region is "governed" by the legal framework established in 1959 by the Antarctic Treaty and the system of legal agreements that have since been negotiated. These ancillary treaties are principally conservation and environmental protection agreements, covering fauna and flora (1964), seals (1972), living marine resources (1980), and the antarctic environment generally. An agreement intended for regulating antarctic mineral resource activities was negotiated in 1988, but it became politically unacceptable to some parties for environmental and sovereignty reasons, and is not likely ever to enter into force. Seven governments (Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom) claim wedge-shaped sectors of the continent, but those claims have been frozen by those governments' participation in the Antarctic Treaty arrangement. As the preeminent government actively involved in antarctic affairs throughout this century, the United States remains the leading state for supplying scientific, legal, and logistical expertise and support to the region.

Increasing levels of shipping activity to the Antarctic since 1975 have brought increasing levels of environmental threats and disasters. Due to inaccurate navigation charts, in March 1989 the Argentine supply ship *Bahia Parasio* ran aground and later sank less than two miles from a U.S. research station on Palmer Peninsula. The 81 tourists on board escaped injury, but some 170,000 gallons of diesel fuel spilled, killing wildlife, befouling the shoreline, and ruining dozens of science projects. This incident highlighted concerns over potential environmental degradation in the Antarctic by minerals and hydrocarbon exploitation activities. Such apprehension over destruction of penguin habitats and krill stocks in circumpolar waters, coupled with the detection in 1985 of massive ozone depletion over the continent, became major reasons for the early abandonment of the proposed 1988 antarctic minerals agreement.

As guaranteed by legal agreements, the Antarctic for the foreseeable future will be a natural preserve for scientists and tourists. No military, resource exploitation, or colonization efforts are anticipated on the continent or, to any appreciable extent, in the circumpolar seas.

Increased global warming has affected antarctic activities recently. This trend will be discussed in more detail in the section on global warming.

Polar navigation and icebreaking

The Coast Guard is the lead agency for domestic ice operations. It is thus authorized to conduct all U.S. ice-breaking operations for the promotion of safety and to assist in meeting reasonable demands of interstate commerce, particularly through the Great Lakes and St. Lawrence Seaway System.

Internationally, the Coast Guard is the lead U.S. agency authorized to conduct ice-breaking operations on waters beyond the jurisdiction of the United States. This includes the high seas and ice-covered waters of foreign countries, pursuant to international agreement. The Coast Guard thus would be the lead agency and main provider of assistance for U.S. shipping activities transiting arctic waters, as well as for providing icebreaker service and logistical support requested by the National Science Foundation for the U.S. Antarctic Program. The Coast Guard also supplies icebreaker escort service for the Department of State in executing the Antarctic Treaty arrangements, as well as bilateral agreements with Canada in the Arctic.

Since 1960, significant developments have occurred in ice-breaking technology that have affected vessel transport to both the Arctic and the Antarctic. The forces pushing these technological advances have been exploration for natural resources around the arctic basin; development of Northern Sea Route by the Soviet Union as an integral part of the Russian Arctic; and the need for multi-mission vessels to transport personnel, logistics, and marine research in the Antarctic.

The length of polar ships ranges from 120 to 450 feet. The principal consideration for the hull of polar vessels is to attain the lowest power required to make progress in ice. Other important considerations in polar ship design include power requirements of the vessel in open water, its maneuvering capability, and protection of propellers. More recently, bow shape has taken on significance as well.

Bow shape is primarily influenced by the mission profile of a polar ship. Over the past decade, bow shape design has progressed in order to increase frame flare, reduce waterline angles, and reduce stem angles. These alterations give the vessels greater efficiency in breaking through and maneuvering in ice.

Another important consideration is stern shape of the vessel. All icebreakers must move astern in ice. Ships must have an icebreaking, or at least ice-deflecting, stern shape. The critical concern while moving astern is ingestion of ice blocks into the propellers, a problem which still greatly complicates ice navigation.

The United States today has in service two principal icebreaking vessels, *Polar Sea* and *Polar Star.* Both are powered by gas turbines and are used for heavy icebreaking, with medium-speed diesel electric power system used for cruising and light icebreaking. A new icebreaker, *Healy*, in presently under construction.

Future trends

For the United States, the thrust of polar attention over the next two decades will shift northward to the Arctic. Increased interest in the Arctic as a source of natural resources will stimulate research on the effects of human activities on the environment and in its protection and management. Greater scientific study will therefore focus on geology and geophysics of the arctic rimland region, as well as on interactions between the ice-covered ocean and the atmosphere, and implications for global climate change.

Over the next 25 years, there will be more winter operations in the ice-covered waters of the Baltic, St. Lawrence Seaway, and western part of the North Sea Route. Accordingly, there will be a steady increase of polar research vessels operating in the Arctic and Antarctic. Polar ships currently are able to operate successfully in heavy ice existing along the Northern Sea Route and the Northwest Passage. By 2020, a number of developments will occur affecting activities along these routes.

Over the next two decades, the Arctic Ocean will undergo profound change. Oil drilling, gas exploration, strategic military operations,

tourism, and fishing will steadily invade the Arctic, northward into the seasonal ice zone. To support these activities, more dredgers, ice breakers, supply and freight ships, cruise ships, and ferries will come into the region. The Arctic's extensive transportation network will continue to develop and improve.

Over next two decades, the northern routes will appear more attractive as commercial opportunities. They entail much shorter distances between the Pacific and Atlantic. There is an existing cargo base, and an underused transportation structure. These activities will stimulate the Russian economy, and offer prospective economic benefits from international investment in Russia. More northerly route options would require larger and perhaps more efficient ship passage, but would also require greater ice-breaking capabilities than are currently available. Greater foreign interest is unlikely unless the navigation season can be extended to nearly a year-round basis.

The Northwest Passage will be used more often, by larger vessels, carrying more cargo, destined for ports in the Asia Pacific. The Northeast Passage will be used more often as a primary shipping route for bulk freight—mostly timber and iron ore—but also for mineral resources such as platinum, gold, tin, and phosphates. Even though the distances are shorter, tanker vessels carrying oil and natural gas will still remain reluctant to transit these northern routes regularly, because of the harsh ice-covered conditions and the higher risks of grounding or hull fractures.

Over the next 20 years, polar navigation technologies will continue to improve in the areas of ship design, propulsion, and route selection. At the same time, we will witness increased consideration for environmental damage to the fragile ecosystems of the polar regions. In 2020, polar vessels will be larger and more powerful so that they can proceed unimpeded through first year, multi-year, and broken sea ice. These ships will use advances from remote sensing systems to navigate and avoid obstacles in their path.

Significantly, if past patterns of global warming continue over the next two decades, by 2020 circumpolar ice formations in both the Arctic and Antarctic will likely contract in area, thickness, and cohesiveness—thus making icebreaking by oceangoing vessels less difficult

than at present. This geophysical development would permit more transportation and resource activities to take place more easily, more often, in more places in the Arctic.

In the south, the Antarctic Treaty System will continue to furnish the legal regime governing maritime activities south of 60° south latitude. There will not be any commercial development of resources on or around the continent—either hydrocarbon or mineral resources, or living marine resources in the Southern Ocean. Commercially, development of such resources will remain less than profitable. It will still be easier to exploit these same resources from other land-based sources elsewhere in Africa, South America, Asia, and the Middle East. Legally, such minerals development will still be prohibited by the Antarctic Environmental Protocol to the Antarctic Treaty; mining and drilling on the continent will still be banned.

The downward trend in U.S. Government budget allocations over the past four years suggests that funds for scientific and logistical activities in the polar south will decrease. U.S. support will continue for the year-round research station at the South Pole and two year-round coastal research stations at McMurdo and Palmer, although budget pressures will reduce funds available for supporting those facilities. Scientific study of global weather and climate patterns will increase, owing to aggravating concern over global warming. More scientific attention also will be given to upper atmospheric physics, dynamics of the continent's ice sheet, and the marine biology and physical oceanography of the Southern Ocean. Budget pressures will nonetheless cause the U.S. Antarctic Research Program to reduce the number of summer camps maintained in Antarctica, and the icebreaking research ship *Nathaniel B. Palmer* and ice-strengthened research ship *Polar Duke* are not likely to be replaced should they be retired from service.

For the foreseeable future, the Antarctica situation has been resolved. The region will remain preserved as a giant scientific outdoor laboratory that will remain free from economic development or mineral resource exploitation. Given the political stability under the Antarctic Treaty system, and assuming that the arrangement remains in place,

activities in the Antarctic will remain relegated to scientists and tourists.

Finally, in order to encourage polar navigation to proceed more safely, expeditiously, and economically, an international "code of polar navigation" will be in place by 2020. This code will develop and harmonize for concerned governments international standards, procedures, and regulations affecting marine transportation through polar waters. Key areas of concern in the code will be safety of life at sea; maintaining environmental safety and pollution prevention; and ensuring safe navigation through ice-covered waters. The International Maritime Organization will be the principal international forum for negotiating, amending, and upgrading this code. An important point, however, is that implementation and enforcement of the polar navigation code will be left principally to the national governments of the arctic rimland states and to flag states whose vessels transit arctic or antarctic seas.

Global warming effects continue

Global warming will affect ice stability in polar regions. In the Arctic, Norwegian scientists using satellite data determined in 1995 that the extent of sea ice decreased by 5 percent between 1978 and 1994. The rate of melting was found to have increased from 2.4 percent per decade to 4 percent per decade by the late 1980s. No detectable rise in sea level occurred, however, since the ice was already floating on the water. Although the cause of melting sea ice was not scientifically ascertained, a reasonable supposition points to increased atmospheric temperature brought about by global warming and climate change in the Arctic.

In February 1995, two events occurred in the Antarctic that suggest increased global warming due to manmade emissions of greenhouse gases. For the first time in recorded history, it was possible to sail around James Ross Island, off the Antarctic Peninsula, as the ice shelf formerly blocking the Gustav Channel has completely disintegrated. Second, an iceberg measuring some 2,900 square kilometers (1,120 square miles) broke off the Larsen Ice Shelf. Scientists at the British Antarctic Survey point to a 2.5° C (4.5° F) warming over the past 50

years as the cause for both events. This warming is significantly greater, and therefore far more alarming, than the 0.5° C (0.9° F) average in global warming observed since the beginning of this century.

As the ocean's water temperature is cooled by melting icecaps, fish species could migrate to new feeding and breeding grounds.

As we stated earlier, a continuation of the past patterns of global warming could cause circumpolar ice formations in both the Arctic and Antarctic to contract in area, thickness, and cohesiveness—all factors that would make icebreaking by oceangoing vessels less difficult. This would facilitate transportation and resource activities in the Arctic.

Because of the improvements in ship design, propulsion, and route selection we cited in the previous subsection, polar navigation will become more attractive and will do less damage to the polar ecosystem than in the past. Relatedly, an IMO "Code of Polar Navigation" will soon be in place. This code will harmonize for concerned governments international standards, procedures, and regulations affecting marine transportation through polar waters.

Ocean dumping declines

Dumping wastes into the oceans became a serious international concern during the 1960s and has since produced a new legal regime aimed at curbing such activities, by governments, corporations, and private persons. This global regime is based on the attainment of minimal standards by all states, which limits their national discretion and makes no allowance for double standards or economic development. At the 13th Consultative Meeting in 1990, parties to the London Dumping Convention resolved to phase out all sea dumping of industrial wastes by 1995, and called for the prohibition of export of wastes for dumping by nonparties.

As regards dumping, which is defined as "the deliberate disposal of wastes or other matter... at sea," governments are obligated under the 1982 Law of the Sea Convention to adopt laws and take means neces-

sary "to prevent, reduce and control pollution" from dumping.[154] The Convention insists that dumping into the ocean not be allowed without the permission of "competent authorities of States."[155] States are directed to "endeavor to establish global and regional rules," and their national anti-pollution legislation "shall be no less effective... than the global rules and standards."[156] It falls upon national governments to ensure that dumping from their vessels is formally prohibited not only in waters of national jurisdiction but also on the high seas. Responsibility for enforcing these prohibitions is also assigned to national governments—in particular, to the coastal state whose waters may be affected or the flag state whose vessel may be dumping.[157]

The principal international instrument designed to discourage dumping in the oceans is the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention). This convention, which was adopted in 1972 and entered into force in 1975, controls and regulates on a global basis the disposal at sea of wastes and any other kind of materials (inclusive of ships and platforms).

The London Dumping Convention provides the legal framework into which the norm against intentional disposal of wastes into the marine environment is cast. The convention obligates contracting parties "to take all practicable steps to prevent pollution of the sea by dumping of waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea."[158] To accomplish this end, the Convention specifically prohibits or restricts certain "black-" or "grey-" listed substances from being dumped into "all marine waters other than the internal waters of states." Contracting

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154.Article 210(1).

155.Article 210(3).

156.Article 210(4)&(6).

157.Article 216.

158.(Annex I, para. 4).

parties are accordingly obliged not to dump harmful substances—including toxins, plastics, and petrochemicals—into ocean space. As such, the London Dumping Convention stands out as a salient international agreement now in force for regulating protection of the marine environment in high sea areas, and one to which the United States is a party.

The anti-dumping convention provides a list of prohibited materials and sets international standards for evaluating materials not specifically listed. Important for protecting the marine environment, among those materials banned from disposal are plastics and other persistent synthetic materials that float or remain suspended in ocean waters such that they materially interfere with fishing, navigation, and other legitimate uses of the oceans.

As defined in Article III 1(a) of the London Convention, dumping is "any deliberate disposal at sea...." Annex I expressly prohibits the dumping of plastic materials, which can ensnare or choke marine mammals in particular. Thus, deliberate discard of fishing nets in the high seas would be forbidden, if, for example, they had been thrown overboard, intentionally cut to avoid detection for fishing violations, or even purposely severed to free unlawfully entangled marine mammals.

The London Dumping Convention is not self-implementing. It relies upon appropriate statutes passed by individual contracting parties for its enforcement. Jurisdiction of each state extends to vessels and aircraft registered in its territory or flying its flag, or which are loading matter to be dumped within that state's territory or its territorial seas, as well as to vessels and platforms under the jurisdiction of a member party believed to be engaged in acts of dumping at sea.[159] Under U.S. law, the London Dumping Convention is specifically integrated into U.S. federal law, and codified in 33 USC 1413 (1994).

Although the London Dumping Convention obviously enlarges the jurisdictional and substantive scope of international law for curbing pollution in the world marine ecosystem, it has some deficiencies.

159.Article VII.

One is that the agreement leaves enforcement to the discretion of each state. The concern here turns on the uncertainty of how each party has implemented the instrument through its own domestic law. Another is that enforcement of the convention remains difficult. Dumping of garbage and debris most often takes place on the high seas, where it is unlikely to be seen or detected by a contracting state's enforcement agents.

For the United States Government, the Environmental Protection Agency and the National Oceanographic and Atmospheric Administration are lead agencies in deciding where dumping by U.S. nationals may occur. The Coast Guard charts approved dumping sites, which are then published in the federal registry. The Coast Guard also furnishes oversight and enforcement of dumping regulations.

The principal U.S. national legislation regulating dumping offshore is the Ocean Dumping Ban Act of 1988.[160] The purpose of the legislation is to strictly limit ocean disposal of any materials that might negatively affect human health, the marine environment, ecological systems, or potential economic activities. Toward these ends, the statute regulates the transportation of materials for the purpose of dumping. A permit issued by the Environmental Protection Agency is required for U.S. nationals to dump waste materials into the sea. The act is enforced by the EPA, in concert with the Secretary of the Army and the Coast Guard. Additional domestic legal authority for enforcing the U.S. ban on dumping toxic wastes into the marine environment comes from the Marine Protection, Research and Sanctuaries Act of 1972 and the Coastal Zone Management Act of 1972.[161]

As of December 31, 1991, the Ocean Dumping Act totally prohibits the dumping of sewage sludge or industrial waste into ocean water. (Under the act, "sewage sludge" is considered to be solid, semi-solid, or liquid waste from a municipal wastewater treatment plant. "Industrial waste" is defined as solid, semi-solid, or liquid wastes generated by a manufacturing processing plant.) The ODA also prohibits the

160. PL 100-688, 33 USC 1401 (1994).

161.33 USC 1401 (1994) and 16 USC 1451 (1994).

dumping of radiological, chemical, and biological warfare agents and high-level radioactive waste into the ocean. The last legal dumping of industrial waste was in September 1988; the last legal dumping of sewage sludge was in July 1991. Dumping of ocean dredge materials is still permitted, as harbors and coastal marine waterways are cleared of bottom siltation. Of note, certain exceptions are provided for dumping without a permit. With a permit, fish waste may be dumped into the ocean if it is not dumped in harbors, enclosed coastal waters, or a place where the EPA has determined that dumping would endanger human health or harm the environment.

The penalties for violation of this statute are strict: Dumping without a permit, or dumping materials that are inconsistent with a permit, is punishable by a fine of $50,000 for each violation.

Future trends

In 2020, dumping of industrial wastes, sewage sludge, and other noxious compounds into the marine environment will be firmly recognized as an unlawful activity. Consequently such dumping activities will continue the present clear declining trend in both volume and number of incidents, both internationally and within waters under U.S. jurisdiction. Relatively little dumping is currently going on offshore the United States, judging from the permitting process. Reliable statistics on unlawful dumping both within the area of U.S maritime jurisdiction and by all states on the high seas are not available. Even so, the dumping of certain substances known to be injurious to the marine environment will continue to be an international concern. Consequently, both the international and national ban on ocean dumping will remain in place, and is even likely to be tightened to accommodate new substances deemed to be harmful to human health or the marine environment by 2020. Ocean dumping without a permit will remain explicitly prohibited, especially for substances containing organohalogen compounds, mercury, cadmium, plastics, mineral oils, and high-level radioactive wastes.

The London Dumping Convention will remain the preeminent international instrument for regulating the dumping of materials that might threaten the marine environment and human health, such as

low-level radioactive waste, and incineration of wastes on board ships at sea.

Concern over oil pollution increases

The 1982 United Nations Convention on the Law of the Sea (1982 LOS Convention) furnishes the highest-level global directives currently available for protecting and preserving the marine environment. The provisions contained in Part XII of the Convention—"Protection and Preservation of the Marine Environment" (Articles 192–237)—do not merely restate existing conventional law or state practice. These articles are actually constitutional in character. They establish a comprehensive framework for the protection and preservation of the marine environment in the context of international law applicable to ocean space. In this respect, Part XII embodies the first serious effort to construct and codify a public international law framework that deals with the degradation of and threat to the world's marine environment. These provisions consequently emphasize the need for global response to problems of marine pollution.

It is important to realize that Part XII was intentionally designed to function as compass law for regional activities. Although the 1982 LOS Convention is norm-setting in general, it does not depend on national authority and unilateral response. It aims at fostering regional cooperation to deal with pollution threats to the marine environment. States are directed to cooperate globally and regionally in formulating rules and standards by giving particular attention to "characteristic regional features."[162] This suggests that regionalism may come to bridge unwieldy global efforts and piecemeal, unpredictable national responses toward protecting the marine environment.

Part XII does not merely furnish standard-setting principles. Rather, it supplies a blueprint for regionally responsive standards. As such, its provisions embody a general framework for anti-pollution measures designed to protect the world marine ecosystem.

162.Article 197.

The 1982 ocean law instrument defines marine pollution in sweeping terms that hold special relevance for protecting the marine environment. It gives national governments chief duty in protecting the ocean environment, as it asserts in Article 192 that "States have the obligation to protect and preserve the marine environment." The obligatory language here is patently obvious. States that violate the mandate to preserve and protect the global marine environment consequently violate international law.[163]

Article 194 legally enforces the duty not to pollute ocean space. The Law of the Sea Convention is concerned with "all sources of pollution of the marine environment," and requires states to take, alone or in concert, all measures necessary to "prevent, reduce and control pollution of the marine environment from any source, using the best practicable means at their disposal and in accordance with their capabilities."

The keystone for substantiating international efforts to protect the marine environment is contained in the package of provisions aimed at worldwide cooperation. States are directed, without exception or qualification, "to co-operate on a global and, as appropriate, on a regional basis... in formulating and elaborating international rules for the... protection and preservation of the marine environment, taking into account characteristic regional features."[164]

The 1982 LOS Convention addresses the threat of marine pollution of the high seas from a source-oriented perspective. Six sources of marine pollution are treated: land-based, national seabed activities, activities in the international seabed area, dumping, vessel-source, and atmospheric.[165] Pollution from all these sources affect the marine ecosystem to varying degrees. The general thrust of these anti-pollution provisions thus is preclusive. They are designed to prevent and dissuade the occurrence of pollution activities, rather than to halt or redress present harmful effects.

163.Article 235.

164.Article 197.

165.Articles 207–212.

The 1982 LOS Convention specifically recognizes the threat that land-based sources of pollution present for the marine environment. States are directed to take legislative action "to prevent, reduce and control pollution of the marine environment from land-based sources..., taking into account internationally agreed rules, standards and recommended practices and procedures."[166] To accomplish this, Article 207 asserts that national legislation should be "designed to minimize to the fullest extent possible, the release of toxic, harmful or noxious substances, especially those which are persistent, into the marine environment."

Vessel-source pollution, along with its impacts on the marine environment, has been of international concern for many years. The 1982 LOS Convention recognizes this situation and obligates states to establish international rules to regulate vessel-source pollution worldwide. National laws adopted by states are to be "no less effective" than generally accepted international rules. Again, enforcement is left in the hands of coastal and port states.[167] The reasoning here is cogent and clear: National governments make anti-pollution law; vessels under the jurisdiction of national governments violate the law; therefore, national governments must enforce the law against those vessels—in port, in waters of national jurisdiction, or on the high seas. Not surprisingly, then, the chief responsibility must expressly fall to flag states to "adopt laws, regulations and take other measures necessary" for implementing those national laws and applicable international rules for their vessels sailing in international waters.[168] In terms of state responsibility for oversight and enforcement of pollution control regulations, this paragraph is crucial for protecting the marine environment. In full, it provides that:

> States shall ensure compliance by vessels flying their flag or of their registry with applicable international rules and standards, established through the competent international organization or general diplomatic conference, and with their laws and regulations adopted in accordance with this

166.Article 207(1).

167.Articles 217 and 218.

168.Article 217(1).

> Convention for the prevention, reduction and control of pollution of the marine environment from vessels and shall accordingly adopt laws and regulations and take other measures necessary for their implementation. Flag States shall provide for the effective enforcement of such rules, standards, laws and regulations, irrespective of where a violation occurs.[169]

Flag states are also expected to certify that their vessels are in compliance with international rules and standards. If alleged violation of international rules or standards by a vessel is reported, the flag state is expected to conduct an "immediate investigation" and "institute proceedings" where appropriate.[170] Significantly, the penalties provided for in the laws and regulations of flag states "shall be adequate in severity to discourage violations wherever they occur."[171] In this regard, flag states are expected to regulate the design, equipment, and operation of vessels, as well as to take measures for preventing accidents that might pollute the marine environment and bring harm to biological diversity in the oceans.

Part XII of the 1982 LOS Convention fixes international obligations for states to protect the marine environment in three main ways. First, governments are explicitly obligated to protect and preserve that marine environment. Put bluntly, governments have the duty not to pollute ocean space and must not condone the actions of nationals that do.

Second, governments are obligated to cooperate on both a global and a regional basis. This involves a basic commitment to make rules, regulations, and standards that undergird the first duty of protecting the marine environment. The critical ingredient here, of course, is international cooperation, which includes information exchange, technological assistance, and implementation assistance. Third, governments are obligated to adopt, enact, and enforce at the national level internationally agreed-upon standards for protecting the

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169.Article 217(1).

170.Article 217, paras. 4, 5, 6 & 7.

171.Article 217 (8).

marine ecosystem. This duty becomes the linchpin for protecting the marine environment. Only governments of states can make international law work effectively. Nevertheless, the duty of implementing national action still remains difficult to secure. Notions of preordained state sovereignty, the lack of resolute political will, and diverse perceptions of what seems best for a state's national interest can override the perceptions of official decisionmakers.

Some conclusions can be posited about the international law that prohibits pollution of ocean space. For one, environmental law generally has been developed on an ad hoc basis. International anti-pollution legislation has evolved largely in reaction to some accident or perceived environmental crisis situation, rather than from prolonged compliance with policies contained in international conventions.

Second, the international law for protecting the marine environment from man-made pollution has similarly evolved piecemeal during the past three decades. The available law has come more in patchwork fashion than as a carefully premeditated, internationally coordinated effort aimed at constructing a coherent legal regime for conserving and protecting biological diversity in the world's oceans.

In spite of the lack of a universal legislative keel, an international law for protecting the world's seas from pollution has evolved. It is in place, and has assumed direct relevance for ocean space.

Third, the anti-pollution provisions in the 1982 LOS Convention are intended neither to replace nor to supersede previous legal commitments made by states in other marine pollution agreements. Instead, these provisions reaffirm and underscore the universal legal obligation to preserve and protect the ocean environment from man-made pollution. To this end, Article 235 succinctly asserts that "States are responsible for the fulfillment of their international obligations concerning the protection and preservation of the marine environment. They shall be liable in accordance with international law."[172] This obligation unquestionably remains a critical norm calling for preservation of environmental integrity of the world oceans.

172.Article 235(1).

Attention to marine pollution has mainly focused on oil and the prevention of maritime accidents. The intense media attention given to oil tanker disasters at sea has promoted greater international involvement in marine pollution control. One outcome was the promulgation in 1973 of an international agreement that was particularly designed to replace the outdated 1954 Convention for the Prevention of the Pollution of the Sea by Oil.

Significantly, the jurisdictional reach of this new agreement, the 1973 International Convention for the Prevention of Pollution from Ships, as modified by its Protocol of 1978 (MARPOL 73/78), applies to the global marine environment. As articulated in its preamble, the purposes of MARPOL 73/78 are to remedy the "deliberate, negligent or accidental release of... harmful substances from ships" as well as "to achieve the complete elimination of intentional pollution of the marine environment... by harmful substances." The agency responsible for promoting MARPOL 73/78 is the International Maritime Organization (IMO). The United States is a party to both the MARPOL Convention and its 1978 Protocol.

Although MARPOL 73/78 deals mainly with pollution of the seas by oil, its regulatory authority also reaches to noxious liquid substances, harmful packaged substances and freight containers, sewage discharge from ships, and disposal of garbage and plastics from vessels at sea. That authority emanates from the special annexes appended to the convention that contain regulations for the enforcement and administration of pollution prevention.

The MARPOL Convention only addresses vessel-source pollution. Each annex to the convention is concerned with a different type of harmful substance or effluent that may be intentionally or accidentally discharged from a ship. Vessel discharge should not be confused with ocean dumping, which concerns the disposal of land-generated wastes. In fact, Article 2, paragraph 3(b) of the convention asserts that discharge does not include "dumping within the meaning of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter...."

The MARPOL Convention was promulgated to bridge gaps left by the 1972 London Dumping Convention. Article 3, paragraph 1(i) of the

Dumping Convention proclaims that dumping excludes "the disposal at sea of wastes or other matter incidental to, or derived from the normal operations of vessels...." In this way, the MARPOL and London Dumping Conventions, both authorized by IMO, have become mutually cohesive for banning pollution activities that might contribute to loss of marine biological diversity.

International organizations assume an important role in monitoring the situation of and codifying the rules for international marine pollution. Preeminent among these is the International Maritime Organization (IMO). Established by the United Nations in 1959 as the Inter-Governmental Maritime Consultative Organization, IMO provides a forum for cooperation among governments on technical matters affecting international merchant shipping. Membership in IMO is intended to represent both traditional maritime states and states that rely on the shipping services of other countries. Though IMO initially placed special emphasis on the safety of life at sea, in recent times its more visible focus has been the prevention and control of marine pollution from ships. To wit, under Article 211 of the 1982 Law of the Sea Convention, IMO is presumed to be the "competent" organization that is to authorize establishment of marine pollution standards. IMO has also been given authority for enforcing the MARPOL 73/78 agreement on the high seas, as well for negotiating new international instruments designed legally to dissuade global marine pollution.

For the United States, two regional conventions hold special legal relevance. First, in 1983 the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (the Cartagena Convention) was negotiated to provide a cooperative regional mechanism for reducing and controlling marine pollution of all kinds within the Caribbean area. The authority of the Cartagena Convention commits contracting parties "to endeavor to conclude bilateral or multilateral agreements... for the protection of the marine environment."[173] To that end, parties are obligated to take "all appropriate measures" to (a) prevent, reduce, and control pollu-

173.Article 3, para. 1.

tion from ships; (b) prevent, reduce, and control pollution caused by dumping; and (c) prevent, reduce, and control pollution caused by coastal disposal or by discharge emanating from internal waters.[174] The United States is a party to this legally binding instrument and is fully obligated to it.

Another important regional environmental agreement is the Protocol on Environmental Protection to the Antarctic Treaty, which was adopted by the Antarctic Treaty Consultative Parties in October 1991. Although this agreement is not yet in force, it provides a comprehensive framework for regulating environmental protection in the antarctic region, inclusive of the ocean space south of 60° South latitude. The fundamental premise undergirding the protocol is stated in its Article 3: "The protection of the Antarctic environment and dependent and associated ecosystems and intrinsic value of Antarctica, including its wilderness and aesthetic values and its value as an area for the conduct of scientific research, in particular research essential to understanding the global environment, shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area."

The Protocol also bans mining and drilling in the Antarctic, inclusive of offshore areas (Article 7), and creates a Committee on Environmental Protection to give advice and make recommendations to the Antarctic Treaty states for policy consideration (Article 11).

Enforcement for compliance under the Environmental Protocol is left to each contracting party to exercise over ships flying their own flag or supporting that government's Antarctic operations. Annex IV also obligates flag states to ensure that all their ships are fitted with retention tanks of sufficient capacity to retain "all sludge, dirty ballast, tank washing water and other oily residues and mixtures" while operating in the region. Contracting governments are made responsible for ensuring that all ships flying their flags have "sufficient capacity" on board for the retention of garbage while within the Antarctic Treaty area and have "adequate facilities" provided for the reception

174.Articles 5, 6, and 7.

of all sludge, dirty ballast, tank washing water, oily residues, and garbage from all ships.[175]

Compliance with the Protocol (and its annexes) is left to governments party to it. Indeed, parties are obligated to take "appropriate measures" to ensure compliance with the Protocol (Article 14). The Protocol also provides in Article 14 that inspections of stations, installations, equipment, ships, and aircraft within the Antarctic Treaty area should be carried out "to promote the protection of the Antarctic environment and associated ecosystems, and to ensure compliance with this Protocol."

Significant to note, neither has the United States government yet come to closure on the implementing legislation required to integrate the Protocol into U.S. federal law, nor has the Antarctic Environmental Protocol entered into force. The United States in September 1996 remains one of only four governments (of the original 26 Consultative Party group) that have yet to complete ratification of the Protocol.

The effect

Worldwide, fewer oil spills have occurred during the past two decades than in previous decades. The vast majority of oil spills are small (fewer than 50 barrels), and the incidence of large spills is relatively low. By 1990, the average number of major oil spills each year had dropped to one-third of the average number per year witnessed in the previous decades: from an average of 24.5 spills a year during the 1970s, to only 8.8 spills during the 1980s.

It is notable that only a few very large oil spills are responsible for a high percentage of the oil spilled. For example, from 1986 to 1995, some 366 spills of over 7 tons occurred in the world oceans, totaling 1,303,000 tons; during the same period, however, 958,000 tons were spilled in just 10 major incidents. The point is that statistics can be severely distorted and skewed by a single large spill.

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175. Article 9(2).

For waters under U.S. jurisdiction, the volume of oil and chemical spills steadily increased between 1993 and 1995 as compared to 1992. Barges and waterfront facilities remain the principal sources of medium and large spills. In 1994, barges accounted for 93 percent of all spill volume from oil spills of 10,000 gallons or more, compared to only 5 percent of spill volume contributed by tankers and freight ships combined. In 1995, tank barges accounted for 75 percent of volume from spills of 10,000 gallons or more, clearly the dominant impact on oil pollution within U.S. waters. Tank barges accounted for all three major oil spills (100,000 gallons or more) in U.S. waters in 1995.

The trend line for major (100,000 gallons or more) and minimum oil spills (10,000 gallons or more) in U.S. waters is downward since the mid-1980s. In 1986 there were 8 major spills and 15 minimum spills, for a spill average of 28 per billion tons of the .816 billion tons of oil shipped through U.S. waters. In 1990, there were 7 major spills and 24 minimum spills, for average of 34 per billion tons of the .93 billion tons of oil shipped through U.S. waters. In 1995, these figures had fallen to 3 major spills and 13 medium spills, for an average of 16 per billion tons of the .984 billion tons of oil shipped through U.S. waters.[176] These statistics suggest that while the volume of ship-borne oil passing through U.S. waters is increasing, the number of spills and volume spilled are declining.

Important also is that the amount of oil and chemicals shipped through U.S. waters has steadily increased over the past 15 years, from 259.9 million gallons in 1982, to 307.8 million gallons in 1990, to 333.1 million gallons in 1995. At the same time, however, the amount of "gallons spilled per million gallons shipped" has dropped dramatically, from 13.5 gallons, to 9.03 gallons, to 5.96 gallons.[177]

Notwithstanding increased tanker traffic, over the past decade, chemical spills in U.S. waters have been relatively few in number and severity. The pattern indicates that about 75 percent of chemical spills fall

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176.U.S. Coast Guard, *Marine Safety and Security and Marine Environmental Protection Programs 1995 Performance Report,* 1996: 23.

177.U.S. Coast Guard, *Marine Safety 1995 Performance Report,* p. 19.

into the 1-to-100-gallon range, and occur most often in rivers, canals, harbors, or "other" locations. Nearly 70 percent of spills occur in internal waters, and less than 10 percent of chemical spill incidents occur in the territorial sea, contiguous zone, or EEZ of the United States. This should not be surprising given that most spills occur during operations, principally in loading and receiving chemical cargoes from tankers, tank barges to land-based facilities. In 1990, most spills reported resulted from unintended discharges (about 35 percent), although many are attributed to equipment and tank failures (28 percent) and structural failures (12 percent).[178] Since then, official U.S. Coast Guard assessments show the causes of most chemical spills in the U.S. to be "unknown." The numbers of spills are remarkably close: 132 in 1993; 152 in 1992; and 137 in 1990.

The number of port calls by deep-draft tanker and cargo vessels to the United States has increased appreciably over the past decade. In 1985, there were no such calls. In 1988, there were 1 tanker and 5 such deep-draft vessel port calls out of a total of 57,621 port calls. In 1993, the numbers grew to 11 tankers and 43 cargo vessels out of a total of 59,029 port calls, and in 1994 at least 28 tankers and 205 cargo vessels called out of a total of 59,029 U.S. port calls. Significantly, the number of Coast Guard enforcement interventions under SOLAS, MARPOL, Loadline Convention, or the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers likewise increased: from 0 in 1985, to 10 in 1988, to 56 in 1993, to 236 in 1996.

Future trends

Over the past decade MARPOL 73/78 has greatly reduced the amount of oil that ships can lawfully discharge into the sea, and bans such discharges completely in certain areas (such as semi-enclosed seas). Over the next two decades, MARPOL 73/78 will furnish the preeminent statutory support for certain operational procedures such as "load on top" (which reduces the amount of mixtures that must be disposed of after tank cleaning) and segregated ballast tanks. IMO will approve many additional resolutions to enhance safety and

178. *Chemical Spills in US Waters, 1990.* Compilation of USCG data.

performance standards aimed at preventing pollution of the sea by oil and other hazardous substances.

The number and volume of international maritime shipping activities will continue to grow in coming decades. More oil and more chemical products will be shipped on more and larger tanker vessels to more U.S. ports in 2020. The number of port calls by foreign deep-draft vessels will also continue to increase. It is reasonable to expect that the number of Coast Guard interventions to enforce international and U.S. legal standards will similarly increase if pollution of the seas by oil or chemical spillage is to be prevented, or at least minimized.

Since 1975, the number of oil spills aggravating pollution of the sea and the volume of oil spilled have noticeably decreased. This downward trend can be attributed mainly to the development of new, more sophisticated international law for regulating international shipping activities, and to the adoption and implementation of stronger legislation by states that mandate enforcement of stricter standards by national regulatory and inspection agencies.

This attitude will be reflected in safety and maritime construction standards, in efforts to enforce the prevention of oil pollution, and in the level of effort for providing adequate pollution response.

Emphasis on sanctuaries and "zoning" for maritime stewardship increases

The Marine Protection, Research and Sanctuaries Act of 1972, as amended, authorizes discrete areas of the marine environment offshore the United States to be designated as National Marine Sanctuaries. The aim here is to protect distinctive natural and cultural resources whose protection and beneficial use requires comprehensive planning and management. National marine sanctuaries, administered by the Sanctuaries and Reserves Division of the National Oceanic and Atmospheric Administration, are specially designated because they contain living or nonliving resources that contribute to the conservation, recreational, ecological, historical, research, educational, or aesthetic value of an area. In 1996, 12 designated National Marine Sanctuaries were adopted offshore California (4), Hawaii (1),

American Samoa (1), Florida (1), Georgia (1), Virginia (1), Georgia (1), Massachusetts (1), and Texas (1). Relatedly, at least 22 other areas have been designated as National Estuarine Research Reserves.

Three primary goals motivate the National Marine Sanctuary Program: (1) to provide enhanced resource protection through conservation and management of the sanctuaries; (2) to support, promote, and coordinate scientific research on and monitoring of resources in the area; and (3) to facilitate multiple uses of the sanctuaries, so long as they are compatible with the principal objective of resource protection.

Over the next two decades, more areas will be designated as National Marine Sanctuaries (as well as National Estuarine Research Reserves). At least three other areas are presently being developed as National Marine Sanctuaries (for the Northwest Straits in Washington state, for the *Monitor* site offshore North Carolina and for Thunder Bay in Michigan). In addition, six new Estuarine Research Reserves are in development. By 2020, more coastal areas are likely to become candidates for designation as National Marine Sanctuaries, largely due to increasing development of mineral, hydrocarbon, and gravel resources offshore Alaska; greater environmental pressures from intensified recreational activities offshore California, offshore Florida, and along the East Coast; and accelerated oil and gas exploration and exploitation offshore Texas and Louisiana in the Gulf of Mexico.

The clear trend over the next two decades will be toward more and greater "zoning" as a strategy for marine stewardship. That is, more offshore areas will be set aside to balance commercial and recreational interests with the needs of a sustainable marine ecosystem. As defined in more recent types of marine sanctuary and protection acts, five area types are designated as special zones: wildlife management, replenishment reserves, sanctuary preservation, existing management, and special use. Each area is designed to reduce damage to the environment, while allowing recreational activities to occur, so long as they are compatible with resource protection. If successful, this "zonal" approach to marine management offshore strategy undoubtedly will be applied to other regions of the United States as well.

By 2020, the highest priority for National Marine Sanctuaries will be the long-term protection of their natural and cultural resources. Essential to the success of such a National Marine Sanctuaries management strategy will be continued education and enforcement of the Marine Protection, Research and Sanctuaries Act, as well as other conservation laws. Education must provide sufficiently relevant information to visitors and users of the sanctuaries so that they can use the sanctuary resources responsibly. Education programs will have to target local citizen, civic, business, and government organizations. In this public education mission, the Coast Guard's role will become instrumental.

The Coast Guard also will have to play a lead role in patrolling and inspecting marine sanctuaries to ensure that users are abiding by regulatory requirements and to respond to any violations of the law. The Coast Guard, moreover, must maintain an adequate investigative capability to ensure proper documentation of and response to unlawful acts that are so complicated as to necessitate specialized, in-depth investigation to determine culpability. As designated marine sanctuary sites increase in number and area, so will the need for Coast Guard participation in education and law enforcement.

Concern for and protection of endangered species continues

The Fish and Wildlife Service (in the Department of Interior) and the National Marine Fisheries Service (in the Department of Commerce) are responsible for maintaining the biological diversity of marine communities that produce food and other products, as well as recreational opportunities, for humans. Various human activities, particularly fishing and coastal development, decrease species diversity within marine ecosystems and alter the ways in which these systems function. This trend of human interference into the natural marine ecosystems will continue during the next 20 years. Consequently, the need will intensify for surveys of existing species to be conducted, for measuring ecosystem functioning, and for mitigating the threats from human encroachment.

The policy now in place to meet increasing needs of species conservation operates under the Endangered Species Act of 1973, and aims to

identify, protect, and conserve the ecosystems upon which federally listed species depend. This trend of protecting endangered species under federal law will continue and indeed expand over the next two decades.

Nearly all of the aquatic environments and biological communities along U.S. coasts have been significantly altered by human impacts since 1950. Due to degraded marine habitats, aquatic ecosystems are less able to support the previous diversity and abundance of native fish and freshwater species. Likewise, losses of suitable aquatic habitats have resulted in significant declines among recreational and nongame fish species and other aquatic organisms. As of late 1996, at least 106 taxa of fish and 57 species of freshwater mussels are on the federal list of threatened or endangered species.

Under the Endangered Species Act, if a species is deemed to be threatened or endangered, it may be placed under special protection so that it might able to recover to sustainable population levels. This recovery effort is especially designed to sustain the survival of each species. Endangered or threatened species in U.S. waters currently under National Marine Fisheries Service jurisdiction fall into four broad categories: (1) cetaceans, of which seven species of whales are considered endangered; (2) sea turtles, of which all six species in the U.S. waters are protected as either endangered or threatened; (3) anadromous and marine fish, of which five species of salmon and two species of sturgeon are protected; (4) and seals and sea lions, of which four particular species have been placed on the endangered list. In addition, under the Marine Mammal Protection Act of 1972, all species of dolphins and porpoises are protected and conserved.

Fishery resources and aquatic ecosystems will remain integral components of our heritage and play important roles in the nation's social, cultural, and economic well-being. Successful protection and management of these endangered species must focus on an ecosystem approach to management that recognizes multiple uses of aquatic ecosystems. Successful management of biological resources must be predicated upon a sound understanding of the species life histories, habitat requirements, and ecosystem processes.

The unmistakable trend in recent years has been to place more marine species on the endangered or threatened species lists. This trend will persist over the next two decades. Moreover, there will be an increasing need to assess and manage marine resources from an ecosystem perspective, thus promoting the concept of Large Marine Ecosystem Program. Large areas of ocean space will increasingly be viewed as separate ecosystems, which must be specially protected and conserved from land-based pollution threats, overharvesting of living resources, and increased habitat degradation. To accomplish such protection and conservation objectives, specially devised ecosystem monitoring, and assessment programs must be planned, implemented, and enforced in U.S. waters over the next decade.

The National Marine Fisheries Service will not have enough inspection or patrol capability to carry out this enforcement responsibility in the year 2020. To protect habitats of endangered species from human activities, as well as to enforce conservation programs for Large Marine Ecosystems, it must find and use greater enforcement means. The Coast Guard appears appropriate and adequately equipped to carry out this mission.

Sources

To identify key trends, we began this effort by reviewing of the writings of "futurists," those who have speculated about the near future. In particular, we concentrated on authors who have written works published during the 1990s that appear to have gained some audience. Among the sources examined were a study prepared by John L. Peterson for the Coast Guard[179] and the writings of Alvin Toffler,[180] John Naisbitt,[181] Paul Kennedy,[182] and others.[183] We did not review works dating from earlier periods, although we examined some surveys of those studies.[184]

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179. John L. Petersen's study originally appeared as U.S. Department of Transportation, U.S. Coast Guard, *The Road to 2012: Looking Towards the Next Two Decades*, March 1993, but was subsequently printed in a slightly revised version as *The Road to 2015: Profiles of the Future* (Corte Madera, California: Waite Group Press, 1994).

180. Toffler has written several studies that have received widespread attention, including *Future Shock*, *The Third Wave*, and *Powershift: Knowledge, Wealth, and Violence at the Edge of the 21st Century* (New York: Bantam Books, 1990).

181. John Naisbitt is best known for *Megatrends* (New York: Warner Books, 1984), but has also written *Megatrends 2000*, and *Global Paradox* (New York: Avon Books, 1994).

182. *Preparing for the Twenty-First Century* (New York: Vintage Books, 1993).

183. Richard Carlson and Bruce Goldman wrote *2020 Visions: Long View of a Changing World* (Stanford, California: Portable Stanford Book Series, 1991), which appeared in a revised version as *Fast Forward: Where Technology, Demographics, and History Will Take America and the World in the Next Thirty Years* (New York: HarperCollins, 1994). We also reviewed recent editions of the *Futurist*, a publication of the World Futures Society, a group dedicated to the study of the future.

Problems with the futurists

Unfortunately, much of this work proved to be of limited value in identifying those trends which would matter to the Coast Guard. First, most futurist trends were too general to be directly useful (i.e., population will grow, the globe will warm, clean water shortages loom); second, some presumed relevant trends turned out not to matter (seabed mining and geothermal energy prospects); and third, some futurist conclusions about technological change, for example, flow from journalists' or amateurs' imagination, rather than from the manipulation of hard or authoritative data. That inevitable and often useful process also results in promulgation of questionable information, and sometimes false conclusions. For example, one study correctly notes that some AIDS patients do not test positively when given the standard HIV tests, and then falsely concludes from this that we may not know the cause of AIDS. In reality, it appears that these patients are so thoroughly infected with HIV that all their HIV antibodies are bound to the HIV virus. Since the tests identify the presence of the disease through detecting antibodies and not through directly detecting the virus, they give an apparent negative result. This example illustrates the tendency of generalists to draw sweeping conclusions based on a failure to understand enough of the subject matter being discussed, and should cause some concern about the overall reliability of the work.

Thus, from our perspective, much of the futurist literature proved to have limited value for purposes of identifying future trends for the Coast Guard.

Where we did find value in using the studies was the identification of areas of agreement and disagreement. The areas of agreement allowed us to identify what appear to be generally accepted trends. Identifying the areas of disagreement made it possible to track the

184.Thomas E. Jones, *Options for the Future: A Comparative Analysis of Policy-Oriented Futures* (New York: Praeger, 1980), systematically reviews some of the seminal works from the 1960s and 1970s, including that of Herman Kahn, Zbigniew Brzezinski, Daniel Bell, and the Club of Rome.

range of alternative implications that sometimes were useful in tracking trends relevant to the study.

Open literature and interviews

Once we understood the generally accepted trends identified by futurists, we relied on more specific open-source research in various areas, covering the widest range of maritime issues. This research covers governmental and pseudo-governmental publications (e.g., congressional, Coast Guard, and IMO documents); and the work of industry and related organizations (e.g., trade associations, trade publications). Finally, we also relied heavily on interviews and discussions with personnel associated with the maritime industry (governmental and private).

List of tables

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Information Memorandum 499

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